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(54) Hearing aid microphone and housing

(57) The present invention includes a compact and economical construction of a microphone (26) wherein the housing is preferably constructed of two identical halves (14,16) that form a chamber (28) in which the microphone is retained. The housing also includes first and second acoustic passages (18,20) in an acoustic relationship with the first and second ports (30,32) of the microphone (26) and extending to an exterior surface of the housing. A switching mechanism (15) is preferably rotatably secured to the housing such that when the switching mechanism (15) is in a first position, the first and second passages (18,20) are in an acoustic receptive state and when rotated to a second position only one of the acoustic passages is in an acoustic receptive state.

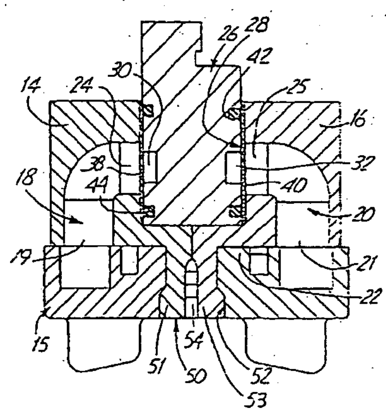

Fig. 3

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Description

[0001] The present invention relates to microphones for use in hearing aids, and in particular, it relates to hearing aids that have both omni-directional and/or directional microphone capability.

[0002] Hearing aids that have the capabilities of a directional microphone and an omni-directional microphone are advantageous to the user. In certain situations an omni-directional microphone is preferred to a directional microphone and vice versa. For example, in a reverberant environment or in an environment that has background noise, a directional microphone will improve speech intelligibility. Directional microphones are also preferred when the sound source is close to the hearing aid user. In addition, attenuation of sounds coming from the rear provide better listening comfort in a noisy environment. Likewise, in other environments, directionality may not be needed, and in fact, may be a detriment.

[0003] For purposes of this application, by directional microphone is meant a microphone having two physically separated acoustic ports which acoustically relate back to opposite sides of a microphone diaphragm. In contrast, an omni-directional microphone has only one acoustic port which acoustically relates to only one side of the microphone diaphragm.

[0004] In the past, two microphones have been included in hearing aids, one an omni-directional microphone and the other a directional microphone. The hearing aid user may switch electronically from one to the other. David Preves, *Directional Microphone Use in ITE Hearing Instruments*, The Hearing Review, July 1997; Olson et al., *Performance of SENSO C9 Directional*, Widexpress, July 1997. This type of hearing aid construction has the disadvantage of the cost of two microphones and the added space that two microphones require.

[0005] There have also been attempts to provide a hearing aid that permits the user to select between directional or omni-directional modes using one microphone. Such hearing aid constructions are described in US-A-3,835,263, US-A-3,836,732, US-A-3,909,556, US-A-4,051,330, and US-A-4,142,072. However, the hearing aid constructions in the above mentioned patents are not conducive to a miniature-in-the ear type of hearing aid construction since the switching mechanisms and the acoustic channels take up too much space.

[0006] The present invention has the object to provide a compact and economical construction of a microphone and housing wherein the user can select between a directional or an omni-directional mode.

[0007] To meet this object, the construction of the invention is structured as claimed in claim 1. Advantageous embodiments of the invention are claimed in the subclaims.

[0008] In a preferred embodiment the microphone is disposed in a housing preferably constructed of two identical halves wherein each housing half includes an acoustic passage. The microphone has first and second acoustic ports and is disposed within the housing in an acoustic relationship with the first and second acoustic passages of the housing, respectively. A switching mechanism is preferably rotatably secured to the housing in an acoustic relationship with the first and second acoustic passages of the housing and is rotatable between a first position wherein the first and second acoustic passages of the housing are in an acoustic receptive state and a second position where either the first passage or the second passage of the housing is blocked by the switching mechanism such that only one of the passages is in an acoustic receptive state.

[0009] Preferred embodiments of the invention will now be described in detail in conjunction wit the accompanying drawings in which

Figure 1 is an exploded perspective view of the microphone housing and the switching mechanism of the present invention.

Figure 2 is an exploded perspective view of the microphone housing and microphone of the present invention.

Figure 3 is a sectional view of the microphone and housing of the present invention.

Figure 4 is a perspective view of one side of the switching mechanism of the present invention.

Figure 5 is an alternative respective view of one side of the switching mechanism of the present invention.

Figure 6 is a partial sectional view of the present invention showing an O-ring between the switching mechanism and the housing and further showing a blockage in the switching mechanism.

Figure 7 is an exploded perspective view of an alternative embodiment of the present invention.

Figure 8 is a perspective view of an alternative embodiment of the present invention where acoustic ports are retained to the microphone by the use of a clip.

Figure 9 is a side view of a first alternative embodiment of the present invention where the acoustic ports are retained to the microphone by a retaining clip.

Figure 10 is a top view of an alternative embodiment of the present invention where the acoustic ports are retained to the microphone by a retaining clip.

Figure 11 is a sectional view of an alternative embodiment of the present invention where the acoustic ports are retained to the microphone by a retaining clip.

Figure 12 is a second alternative embodiment of the present invention where the acoustic ports are welded to the sides of the microphone.

Figure 13 is a top view of the second alternative

embodiment of the present invention where the acoustic ports are welded to the sides of the microphone.

Figure 14 is a sectional view of the second alternative embodiment of the present invention where the acoustic ports are welded to the sides of the microphone.

Figure 15 is a third alternative embodiment of the present invention where a first acoustic port is continuously open and the second acoustic port can alternatively be opened or shut by a rotating mechanism.

Figure 16 is a sectional view of the third alterative embodiment of the present invention.

Figure 17 is a top view of the third alternative embodiment of the present invention.

Figure 18 is a sectional view of the third alternative embodiment of the present invention.

Figure 19 is a partial perspective view of the a fourth embodiment of the present invention where one acoustic port is continuously open and where a second acoustic port can be alternatively opened or closed by a sliding mechanism.

Figure 20 is an exploded perspective view of the fourth alternative embodiment of the present invention viewed from below the invention.

Figure 21 is an exploded perspective of the top side of the fourth alternative embodiment of the present invention.

Figure 22 is a top view of the fourth alternative embodiment of the present invention.

Figure 23 is a sectional view of the sliding mechanism and acoustic ports of the fourth alternative embodiment of the present invention.

Figure 24 is a sectional view of the fourth alternative embodiment of the present invention.

Figure 25 is a partial perspective view of a fifth alternative embodiment of the present invention.

Figure 26 is a top view of the fifth alternative embodiment of the present invention.

Figure 27 is a sectional view of the fifth alternative embodiment of the present invention detailing the configuration of the acoustical ports.

Figure 28 is an additional sectional view of the fifth alternative embodiment of the present invention.

Figure 29 is a partial perspective view of a sixth alternative embodiment of the present invention where a slidable mechanism does not include an acoustic opening.

Figure 30 is a top view of the sixth alternative embodiment of the present invention.

Figure 31 is a sectional view of a sixth alternative embodiment of the present invention disclosing the configuration of the acoustical ports.

Figure 32 is a sectional view of the sixth alternative embodiment of the present invention.

Figure 33 is an exploded perspective view of a seventh alterative embodiment of the present invention wherein a retaining clip holds the pieces of the body together.

Figure 34 is a perspective view of the seventh alternative embodiment of the present invention.

Figure 35 is an additional view of the seventh alternative embodiment of the present invention while viewing the invention from the bottom.

Figure 36 is a bottom view of the seventh alternative embodiment of the present invention.

Figure 37 is a top view of the seventh alternative embodiment of the present invention.

Figure 38 is a sectional view of the seventh alternative embodiment of the present invention along the long axis of the microphone.

Figure 39 is a sectional view of the seventh alternative embodiment of the present invention along the sectional line across the short axis of the microphone.

Figure 40 is an exploded perspective view of an eighth alternative embodiment of the present invention where the switching mechanism slidably engages the acoustic ports.

Figure 41 is a perspective view of the eighth alternative embodiment of the present invention as being viewed from above the invention.

Figure 42 is a perspective view looking from the bottom of the eighth alternative embodiment of the present invention.

Figure 43 is a top view of the eighth alternative embodiment of the present invention.

Figure 44 is a sectional view of the eighth alternative embodiment of the present invention along the section line A-A of Figure 43.

Figure 45 is a bottom view of the eighth alternative embodiment of the present invention.

Figure 46 is a sectional view of the eighth alternative embodiment of the present invention along the sectional line B-B of Figure 43.

Figure 47 is a sectional view of the acoustical port in the eighth alternative embodiment of present invention along the section line C-C of Figure 45.

Figure 48 is an exploded perspective view of a ninth alternative embodiment of the present invention where the invention is a behind the ear hearing aid.

Figure 49 is a top view of the ninth alternative embodiment of the present invention.

Figure 50 is a partial side view of the ninth alternative embodiment of the present invention.

Figure 51 is a sectional view along the section line A-A of Figure 50 of the ninth alternative embodiment of the present invention.

Figure 52 is a sectional view along the section line B-B of Figure 50 of the ninth alternative embodiment of the present invention.

Figure 53 is a perspective view of a tenth alternative embodiment of the present invention where a second acoustic port can either be opened or blocked by a rotational switching mechanism in a

behind the ear hearing aid.

Figure 54 is an exploded perspective view of the tenth alternative embodiment of the present invention where the switching mechanism for a behind the ear hearing aid is rotatably engaged.

Figure 55 is a partial top view of the tenth alternative embodiment of the present invention.

Figure 56 is a partial side view of the tenth alternative embodiment of the present invention.

Figure 57 is a sectional view of the tenth alternative embodiment of the present invention as viewed along the section line A-A as illustrated in Figure 56.

Figure 58 is an exploded perspective view of an eleventh alternative embodiment of the present invention where a second acoustical port can either be opened or blocked by a horizontal sliding mechanism along the side of a behind the ear hearing aid.

Figure 59 is a perspective view of the eleventh alternative embodiment of the present invention.

Figure 60 is a partial top view of the eleventh alternative embodiment of the present invention.

Figure 61 is a partial side view of the eleventh alternative embodiment of the present invention.

Figure 62 is a sectional view of the eleventh alternative embodiment of the present invention as viewed along the section line A-A as illustrated in Figure 61.

Figure 63 is a perspective view of a twelfth alternative embodiment of the present invention.

Figure 64 is an exploded perspective view of the twelfth alternative embodiment of the present invention.

Figure 65 is an exploded perspective view of the twelfth alternative embodiment of the present invention.

Figure 66 is a top view of a twelfth alternative embodiment of the present invention.

Figure 67 is a sectional view of the twelfth alternative embodiment of the present invention.

Figure 68 is an additional sectional view of the twelfth alternative embodiment of the present invention.

[0010] The present invention provides in a hearing aid selectability between an omni-directional and a directional microphone mode in an economic and compact construction. Referring to Figure 1 of the drawings, the hearing aid construction 10 of the present invention is generally indicated at 10. The hearing aid construction 10 includes a housing 12 and a mechanical switching mechanism 15. As further illustrated in Figure 2, the housing 12 preferably includes matching and preferably identical housing halves 14 and 16. Each housing half 14 and 16 includes an acoustic passage 18 and 20, respectively. The acoustic passages 18 and 20 extend from a common exterior surface 22 of the housing 12 as indicated by exterior openings 19 and 21 respectively, as best illustrated in Figure 1. The acoustic passages 18 and 20 extend from the exterior openings 19 and 21 to interior openings 24 and 25 as best illustrated in Figure 3.

[0011] A directional microphone 26 is positioned within a microphone chamber 28 that is formed by the housing halves 14 and 16. The directional microphone 26 is of standard construction having first and second acoustic ports 30 and 32 disposed on opposite sides of a diaphragm (not shown). The acoustic ports 30 and 32 are positioned to be in an acoustic relationship with the acoustic passages 18 and 20 through openings 24 and 25 of the housing halves 14 and 16, all respectively, when the microphone 26 is positioned within the chamber 28.

[0012] The housing halves 14 and 16 may be joined together by any suitable method such as illustrated in Figure 2, in which each housing half includes a male pin 34 extending from an interior surface 35 and a mating hole or female member 36 disposed on the same surface of the same housing half to receive a male member (not shown) similar to male member 34 and the male member (not shown) extending from the other housing half 16. Similarly, the housing half 16 also has a mating hole or a female member (not shown) similar to female member 36 of the housing 12 and positioned to receive the male member 34. The male members are of a size and shape to snap fit within the respective female members to secure the housing halves 14 and 16 together to form the housing 12.

[0013] Acoustic dampers 38 and 40 are positioned adjacent to the openings 24 and 25, respectively. Alternatively, the dampers 38 and 40 can be positioned inside the microphone or at the entrance of openings 19 and 21. O-rings 42 and 44 are disposed between the dampers 38 and 40 and the acoustic ports 30 and 32, as best illustrated in Figure 3. The O-rings are made of a compressable polymer such as a natural or synthetic rubber and are necessary to provide a tight acoustic seal. The O-rings 42 and 44 eliminate any leakage due to variation in construction of the housing halves and the microphone and dimensional variations that may result from snapping together the housing halves 14 and 16. The O-rings 42 with the acoustic passages 18 and 20 being part of the housing 12 provide a very efficient acoustic path with virtually no leakage. Alternatively, an ultraviolet stabilized silicone adhesive may be used instead of O-rings 42 to provide an acoustic seal.

[0014] A male connecting pin member 50 extends from the housing surface 22. The male member 50 is positionable within a receiving aperture 52 in the switching mechanism 15. The male member 50 is comprised of two halves each extending from housing halves 14 and 16, respectively, and which are joined together when the two housing halves 14 and 16 are snap fitted to create the housing 12 and the chamber 28 for the microphone 26. A slot 54 extends through the center of

the male pin member 50 and defines two prong sections 51 and 53 that are pushed toward each other as the pin member 50 is inserted within the receiving aperture 52.

[0015] As best illustrated in Figure 3, the member 50 has a frustro-conical end portion and receiving aperture 52 has a frustro-conical female shaped end portion which is configured to mate with the member 50. It will be appreciated that the prong sections 51 and 53 bend inwardly as the frustro-conical end portion of the male member is inserted into the initial narrower section of the receiving aperture 52 and then extend outwardly when the frustro-conical end portion of the male member is inserted into the frustro-conical section of the aperture 52 due to the inherent spring force of the prong sections 51 and 53. The annular incline of the frustro-conical member 50 in cooperation with the spring force of the prong sections 51 and 53 provides a force that pushes the switching mechanism against the surface 22 of the housing 14.

[0016] The switching mechanism 15 preferably has a circular perimeter corresponding to the general circumference and diameter of the housing 12 and is preferably rotatable about the member 50. The switching mechanism 15 includes acoustic switching ports 54, 56 and 58, and a plugged port 59 as best illustrated in Figure 4 and a stop member 60 extending in a direction towards the surface 22 when the switching mechanism 15 is rotatably secured to the housing 12.

[0017] Stop tabs 62 and 64 are disposed on the surface of the housing 12, each tab extending from respective housing halves 14 and 16. The tabs 62 and 64 extend toward the switching mechanism 15 such that when the mechanism 15 is secured to the housing 12, the tabs 62 and 64 will be engaged by the stop member 60. A plurality of finger tabs 66 extend from an outer surface 68 of the switching mechanism 15 such that the tabs are engagable by a human finger or an instrument such as a screwdriver for rotating the switching mechanism 15.

[0018] In an alternative embodiment, as illustrated in Figures 5 and 6, the switching mechanism 70 includes three acoustic ports 72, 74 and 76 and an acoustic blocking port 78. The switching mechanism 70 is otherwise identical to the switching mechanism 15 of Figure 4 except for the following variation. Each of the acoustic ports 72, 74 and 76 and the acoustic blocking port 78 have an O-ring 80 positioned within a recess 82 of a distal end 84, as illustrated in Figure 6, wherein only the acoustic blocking port 78 is illustrated. The acoustic ports 72, 74 and 76 are identically configured with respect to the O-ring 80. The O-ring 80 of each of the acoustic ports 72, 74 and 76 and the acoustic block port 78 are in an acoustic sealing relationship with the exterior surface 22 of housing 12. Therefore, when the ports 72 and 74 are aligned respectively with both acoustic passages that are in acoustic relationship with the microphone, the hearing aid construction of the present invention is in a directional microphone state. When the acoustic port 76 and the acoustic blocking port 78 are aligned with the acoustic passages, then since only one acoustic passage is connected with one acoustic port, the hearing aid construction of the present invention is in an omni-directional mode. As illustrated in Figure 6, the blocking acoustic port includes a blockage 86 which prevents any acoustic waves to enter the passage and affect the microphone.

[0019] When the switching mechanism 15 is secured to the housing 12, as best illustrated in Figure 3, the switching mechanism 15 is rotatable to a position in which the stop member 60 engages stop tab 62. When the member 60 engages tab 62, the microphone construction of the present invention is in a directional mode with acoustic switching port 54 in an acoustic relationship with acoustic passage 20 and acoustic switching port 56 in an acoustic relationship with acoustic passage 18. When the switching mechanism 15 is rotated in an opposite direction such that the member 60 engages stop tab 64, the switching ports 54 and 56 are disconnected from an acoustic relationship with the acoustic passages 18 and 20 while switching port 58 is positioned in an acoustic relationship with acoustic passage 20 thereby placing the microphone construction of the present invention in an omnidirectional mode. The acoustic passage 18 when the microphone construction of the present invention is in the omni-directional mode is blocked by plugged port 59 from receiving sound by the switching mechanism 15.

[0020] In Figures 7-68, twelve alternative embodiments of the present invention are illustrated. In an embodiment illustrated in Figures 63 through 68, a switching mechanism 600 is positioned on an outer surface of a faceplate 602 in close proximity to a battery compartment 604.

[0021] As further illustrated in Figure 65, a directional microphone cartridge 606 is positioned on an inside surface 608 of the faceplate 602. As clearly illustrated between Figures 64 and 65, the faceplate 602 includes acoustic openings 610 and 612 which extend through the faceplate 602 from an outside surface 614 to an inside surface 616. The acoustic openings 610 and 612 are in acoustic relationship with acoustic passages 618 and 620 of the directional microphone 622.

[0022] The acoustic switching mechanism 600 includes a rotatable switching element 624 rotatably secured to the outside surface 614 of the faceplate 602 by a male pin 626 as best illustrated in Figures 63, 64, 65, 67 and 68. The male pin 626 includes a number of ridges 628 which engage an aperture 630 that extends through the faceplate 602. It will be appreciated that the aperture 630 is equidistant from acoustic openings 612 and 610 which is important in relation to the movement of the switching element 624 to acoustically switch between a directional and an omni-directional mode of the hearing aid.

[0023] As best illustrated in Figure 63, the acoustical switching element 624 has directional acoustic open-

ings 632 and 634 positioned equidistant from the center of the switching element or pin member 626 and positioned to overlie the acoustic openings 612 and 610 of the faceplate 602. The switching element 624 also includes omni-directional acoustic opening 636 which is positioned on the element 624 to overlie either acoustic opening 612 or 610 depending on how the element 624 is attached to the faceplate.

[0024] The acoustic passages 618 and 620 extend into the faceplate 602 and the openings 610 and 612 are of a size that accommodate and engage the outside surfaces of passages 618 and 620. The openings 610 and 612 are larger in diameter on the surface 616 then on the surface 614, as illustrated in Figure 68.

[0025] A stop pin 638 is fixedly attached to the faceplate 602 by frictionally fitting the stop pin 638 into opening 640 in the faceplate 602.

[0026] Directly across from the acoustic opening 636 is positioned an acoustic blocking member 642 for directly overlying one of the acoustic openings 612 or 610 of the faceplate 602 when the switching element 624 is positioned in the omni-directional mode, that is when opening 636 overlies one of the acoustic openings 612 or 610.

[0027] O-ring seals 644 are attached to the underside of the switching element 624 for providing an acoustically tight seal for the directional acoustic openings 632 and 634, and the omni-directional opening 636, and the acoustical blocking element 642, as best illustrated in Figure 65.

[0028] The element 624 also includes stop member engaging cavities 646 positioned on an underside thereof, one of which overlies the stop member 638, as best illustrated in Figure 67. The inside surfaces of the cavity 646 engage the stop member 638 as the element 624 is rotated about the male pin member 626. The inside surfaces of the cavities 646 are formed such that when the member 624 is rotated in one direction and the inside surface of one end of the cavity is engaged, both directional acoustic openings 632 and 634 are positioned to directly overlie acoustic openings 612 and 610 thereby placing the openings 632 and 634 in an acoustic relationship with acoustic passages 618 and 620 of the microphone 622 and place the hearing aid in a directional microphone mode.

[0029] Likewise, when the element 624 is rotated in an opposite direction, the stop pin member 638 engages an opposite surface of the cavity 646 thereby aligning the omnidirectional opening 636 over either opening 612 or 610 in the faceplate 602 and the acoustic blocking element 642 over the other opening to place the microphone in an omni-directional mode. A plurality of tab members 648 extend outwardly from the switching element to aid in rotating the element 624 through use of a finger or a tool.

[0030] While one embodiment of the present invention included a multiple acoustic port switching element which is rotatably attached to the main body, an alternative embodiment is to slidably attached the multiple acoustic port switching element to the main body as illustrated in Figures 40-47.

[0031] The embodiment 350 includes a directional microphone 352 having acoustic ports 354 positioned on opposing sides. Housing halves 356 and 358 are secured to each other with the microphone 352 disposed therebetween. Each housing half 356 and 358 includes acoustic passages 360 and 362, respectively, as best illustrated in Figure 44. Dampers 364 and O-rings 366 are included to provide an acoustical seal. Acoustical dampers can be mounted inside the microphone as an option. A retaining ring 368 engages collar halves 370 and 372 of housing halves 356 and 358, respectively, to retain the housing halves together. Each housing half also includes a pin member 374 and an aperture 376 for receiving a pin-like member 374 of the opposing housing half to aid in retaining the housing halves together to form a single housing.

[0032] The switching element 380 unlike the rotatable switching element of Figures 1-6 and 63-68 is a sliding element slidable in a direction generally indicated by arrows 382 of Figure 42. Each housing half 356 and 358 includes an inwardly facing elongated track member 384 and 386 that engages conforming track members 388 and 390, respectively, of the switching element 380, as best illustrated in Figure 44.

[0033] The sliding element 380 includes directional microphone openings 392 and 394 which, when positioned to be in acoustic relationship with acoustic passages 360 and 362, place the microphone construction in a directional microphone mode. The sliding element further includes omni-directional opening 396 which when slid over acoustic passage 362, the sliding element then blocks passage 360, placing the microphone 352 in an omni-directional mode. A tab member 398 is included to aid in moving the switching element 380 between a directional and an omni-directional position.

[0034] The position of the switching element 380 is determined by a stop member 400 extending from the housing half 358 into a cavity 402 within the switching element 380, as best illustrated in Figures 44 and 45. As can best be seen in Figure 45, the travel of the switching element in a general direction of arrows 382 is determined by the stop member 400 engaging end walls of the cavity 402. Moving the switching element so that the stop member engages one end wall will place acoustic openings 392 and 394 in acoustic relationship with acoustic passages 360 and 362 to place the microphone in a directional mode. Moving the switching element 380 in the other direction will engage an opposite wall of the cavity 402 thereby placing acoustic opening 396 over acoustic passage 362 while blocking acoustic 360 to place the microphone in an omni-directional mode.

[0035] Alternative means of retaining the acoustic passages to the acoustic ports on the microphone are illustrated in Figures 7-11 and Figures 12-14. Figures 7-

11 show an alternative embodiment of retaining the acoustic passages to the acoustic ports on the microphone. Figures 12-14 illustrate a second alternative embodiment retaining the acoustic passages to the acoustic ports on the microphone.

[0036] With respect to Figures 7 through 11, the microphone is indicated by reference character 100 while the microphone of Figures 12 through 14 is generally indicated by reference character 102. Generally speaking, the microphones operate in a like manner, and it is their construction that is slightly different.

[0037] With respect to microphone 100, acoustic passages 104 and 106 are placed in acoustic relationship with microphone acoustic ports 108 and 110 by a retaining clip 112. Each acoustic passage 106 includes a flange member 118. O-rings 120 are positioned about an end of the acoustic channel adjacent the respective microphone ports 108 and 110 to provide an acoustic seal.

[0038] The retaining clip 112 has on both sides of the main body 114 of the microphone 100 resilient spaced-apart fingers 116. As illustrated in Figure 8, the fingers 116 are positioned on opposite sides of the main body 114 of the microphone and engage the flanges 118 of the acoustic passages 104 and 106.

[0039] The embodiment of the microphone 102 illustrated in Figures 12 through 14 includes a main body 126 to which acoustic passages 128 and 130 are welded in acoustic relationship with acoustic microphone ports 132 and 134. The embodiment 102 of Figures 12 through 14 is absent the retaining clip and O-rings of embodiment 100. Welding of the passages to the main body 126 provides the acoustic seal. Flanges 136 provide a stable base for welding of the acoustic passages 128 and 130 to the main body of the microphone.

[0040] Figures 33 through 39 illustrate a directional microphone construction useful for an in-the-ear hearing aid.

[0041] The microphone construction 300 includes a directional microphone 302 having acoustical ports 304 on opposing sides and is contained between housing halves 306 and 308. A combination of a damper screen 310 and O-ring 312 is included between the microphone ports and the housing halves to provide an acoustic seal.

[0042] The housing halves 306 and 308 are held together by a retaining ring 316 to create a singular housing. The housing halves also include collars 318 and 320 that extend through an aperture 322 of the rotary switching element 324 to further hold the housing halves 306 and 308 together on an end opposite from the retaining ring 316. The switching element 324 is held in a rotatable relationship with respect to the housing halves by a male pin being pressed fitted into an aperture 328 formed by the collars 318 and 320. The pin 326 has a head 330 that is larger than the opening 322 to retain the switching element 324 against the housing halves 306 and 308.

[0043] The acoustic features of the switching element 324 and of the housing halves 306 and 308 are virtually identical to the switching element defined in Figures 63-68.

[0044] Besides manipulating the openings of both acoustic ports, alternative embodiments include the manipulation of one acoustic port opening.

[0045] An additional alternate embodiment 140 of the present invention is illustrated in Figures 15 through 18. The embodiment 140 of Figures 15 through 18 includes a rotatable switching element 142 similar to the rotatable switching element illustrated in Figures 1 through 6 except that the element includes only one acoustic opening 144. The element 142 is rotatably attached to the faceplate 150 in a similar manner as the switching element in Figures 63 through 68.

[0046] As best illustrated in Figure 16, a directional microphone 143 includes acoustic ports 146 and 148 disposed along axes that are perpendicular to each other. The port 146 engages an opening or aperture 151 of the faceplate 150 and is positioned beneath the switching element 142. The other port 148 is connected by an acoustic passage 152 to another opening 154 in the faceplate 150. The opening 154 is positioned to be outside of the perimeter of the switching element 142. A wind screen 156 covers the opening 154.

[0047] The switching element 142 includes an acoustical blocking element 160 positioned preferably 90 degrees from the acoustic opening 144. In the particular embodiment illustrated in the drawings, the blocking element 160 is disposed directly beneath an outwardly extending tab member 162.

[0048] A stop pin member 164 is frictionally fit into an aperture 165 of the faceplate 146 as best illustrated in Figure 16. The switching element 142 includes a cavity 166 within which the stop element 164 is positioned, as best illustrated in Figure 17. As illustrated in Figure 17, with the stop element engaging one inside surface of the cavity 166, the opening 144 is positioned over the acoustic opening 151 of the faceplate 146 and is in acoustic relationship with the acoustic port 146 of the microphone. In this position, the microphone is in a directional mode since the other acoustic port 148, of course, is in acoustic relationship with the opening 154 of the faceplate.

[0049] If the switching element 142 is turned 90 degrees, and the stop element 164 engages an opposite end surface of the cavity 166, the blocking element 162 is then positioned over the opening 151 and the acoustic port 146 of the microphone, placing the hearing aid in an omni-directional mode.

[0050] Another alternate embodiment of the present invention is illustrated in Figures 19 through 23. The embodiment 170 is similar in concept to the embodiment illustrated in Figures 15 through 18. As best illustrated in Figure 23, a directional microphone 174 includes acoustic ports 176 and 178 positioned along

axes that are perpendicular to each other. The port 176 is disposed between a sliding switching element 180 while the port 178 is in acoustic relationship through an acoustic passage 182 with an opening 184 in the faceplate 186. The opening 184 is outside of the travel of the switching element 180 such that the opening 184 is not covered by the switching element 180.

[0051] The microphone 174 is disposed in a housing 175 that includes a pair of spaced apart posts 188 that extend through openings 190 in the faceplate 186, as best illustrated in Figure 20. The posts 183 have tracks 192 on opposing sides. The switching element 180 has elongated slots 194 and 208 of a size and shape that conform to the tracks 192 and the ends of the posts 188 that extend beyond the outer surface 196 of the faceplate 186, as best illustrated in Figures 19 and 21. As can be appreciated, the switching element 180 through its engagement of the ends of the posts 188 that extend above the surface 196 slides along the posts, and retains the microphone 174 on the opposite side of the faceplate 186 in position.

[0052] Similar to the switching element of Figures 16 through 18, the switching element 180 also contains a single acoustic opening 198. The switching element 180 also includes an acoustic blocking element 200 that is positioned directly beneath the tab 202, as best illustrated in Figures 21 and 22. As can be appreciated, the travel of the switching element 180 positions acoustic opening 198 over opening 204 in the faceplate 186 thereby placing the opening 198 in acoustic relationship with the port 176 of the microphone to place the microphone in a directional mode. Moving the sliding element such that the blocking member 200 is positioned over the opening 204, blocks the port 176 and places the microphone in an omni-directional mode.

[0053] As can best be seen in Figure 22, the slot 194 has an inside or inner surface 204 and the slot 208 positioned on an opposite side of the element has an inside surface 210. It will be appreciated that the travel of the switching element 180 is limited by engagement of the posts 188 between the surfaces 206 and 210 of the slots 194 and 208, respectively. As specifically illustrated in Figure 22, the travel of the switching element 180 is limited by the inside surface 210, thereby placing the opening 198 in acoustical relationship with the port 176, and thereby placing the microphone in a directional mode. If the sliding element were moved in an opposite direction such that the post 188 would engage the inside surface 206, the microphone would be placed in an omni-directional mode.

[0054] As in the embodiments previously discussed, O-rings 212 are positioned between the opening 198 and the opening 204, and the blocking element 200 so that an acoustic seal is created with the opening 204.

[0055] An alternate embodiment 220 of the present invention is illustrated in Figures 25 though 28. The embodiment 220 is similar to the embodiment illustrated in Figures 16 through 18. The embodiment 220 includes a switching element 222 identical to the switching element 142. The primary difference between the embodiment 220 and the embodiment 140 is that a directional microphone 224 is retained in place by retaining block 228, as best illustrated in Figures 27 and 28. The retaining block includes an acoustic passage 230 for providing passage to sound waves from opening 230 in the faceplate 226 to port 234 of the microphone 224. The other port 236 of the microphone 224 is disposed beneath the switching element 222 in a manner that was described with respect to the embodiment of Figures 15 through 18. O-rings 238 are disposed between an inner surface of the faceplate 226 and the block 228 to provide an acoustic seal for port 236 and acoustic passage 230.

[0056] Another alternate embodiment 250 of an in-the-ear directional/omni-directional microphone structure of the present invention is illustrated in Figures 29 through 32. The embodiment 250 is similar to the embodiment 170 described with respect to Figures 19 through 24. The microphone 252 and its securement to faceplate 254 is very much the same as was described with respect to Figures 23 and 24. The difference between embodiment 250 and embodiment 170 is the construction of the switching element 256. The switching element 256 is a sliding type switching element slidable in a direction of arrow 258 as illustrated in Figure 29. The difference between the switching element 256 and the switching element 198 is that the switching element 256 does not have an acoustic opening. Instead, both acoustic openings are on the faceplate 254 and are not covered by the switching element 256 when the microphone is in a directional microphone mode, as best illustrated in Figure 30. In Figure 30, opening 260 and opening 262 are not covered by the switching element 256, placing the microphone 252 in a directional microphone mode.

[0057] To place the microphone 252 in an omni-directional microphone mode, the switching element is moved in the general direction of arrow 264, as illustrated in Figure 30, thereby placing acoustical blocking element 266 over opening 260, leaving only acoustic opening 262 uncovered to accept sound waves, thereby placing the microphone 252 in an omni-directional mode.

[0058] The present invention is not limited to in the ear hearing aids but also is useful in behind-the-ear (BTE) hearing aids. Figures 48 through 52 illustrate a behind-the-ear hearing aid housing with an omni-directional/directional microphone construction. The embodiment 420 illustrated in Figure 48 includes a top housing half 422 and a bottom housing half 424 that are joined together to make a single unitary housing for housing various components of a behind-the-ear hearing aid including the microphone construction. A main body of a microphone 426 is positioned in a compartment 428. The directional microphone includes two acoustic ports 430 and 432, as best illustrated in Figure 49. The

acoustic port 432 is acoustically connected to an opening 434 in the housing 425 by acoustic conduit 436. A damper screen 438 and an O-ring 440 are positioned at the outlet of acoustical conduit 436 along with a wind screen 442.

[0059] A switching element 444 is slidably secured within the housing 425 to slide within opening 450 in a general direction indicated by arrows 452. The switching element 444 is secured to the housing 425 through the use of tracks 454 disposed along inwardly facing edge surfaces 454 that meet with tracks 456 disposed along opposing edge surfaces of the switching element 444.

[0060] The switching element includes on acoustic opening 460 which is combined with an O-ring 462 such that when the opening 460 is positioned over the acoustic port 430, an acoustic seal is created. A second O-ring 464 is positioned over an acoustic blocking element 466 (best seen in Figures 50 and 51) to provide an acoustic seal when the blocking element is positioned over the acoustic port 430. An outwardly extending tab member 468 permits the user to easily move the switch in a general direction indicated by arrow 452.

[0061] When the opening 460 of the switching element 444 is positioned over the acoustic port 430, the microphone 426 is in a directional mode since both acoustic ports 430 and 432 can receive sound waves.

[0062] When the switching element 444 is positioned such that acoustic blocking element 466 is positioned over the port 430, then only the port 432 receives sound waves, thereby placing the microphone construction in an omni-directional mode.

[0063] Figures 53 through 57 illustrate an alternate behind-the-ear housing and microphone construction generally indicated at 480. The embodiment 480 also includes first and second housing halves 482 and 484, respectively, joined together to form a unitary housing indicated at 486. In a compartment 488, a main body of a directional microphone 490 is positioned. The directional microphone 490 is the same as the directional microphone described with respect to Figures 48 through 52. The directional microphone 490 includes a first acoustic port 492 and a second acoustic port 494. The second acoustic port 494 is acoustically connected to the exterior of the housing through acoustic conduit 496 that is acoustically connected to opening 498 in the housing 486, as best illustrated in Figures 54 and 55. A damper screen 500, O-ring 502 and wind screen 504 complete the acoustic construction at the outer surface of the housing 486. Acoustic damper can be mounted inside the microphone this is true for all of the designs described herein.

[0064] The switching element 506 is cylindrical in configuration and includes an outer track 508 on its perimeter that engages an inwardly facing track 510 that defines an opening 512 of the housing 486 and within which the switching element 506 is positioned. The switching element is rotatable in the general direction of arrow 514.

[0065] The switching element 506 includes an acoustic opening 518 that is positionable over the acoustic port 492 of the microphone 490. When the opening 518 is positioned over the acoustic port 492, the microphone 490 is in a directional mode since sound waves reach both acoustic ports 492 and 494.

[0066] To place the microphone construction in an omni-directional mode, the switching element 514 is rotated to position an acoustic blocking element over the port 492 thereby preventing sound waves from reaching the microphone through port 492 thereby placing the microphone in an omni-directional mode. Tab member 520 is used to turn or rotate the switching element 514.

[0067] O-rings 522 and 524 are used to provide acoustical seals to the acoustic opening 518 and to the acoustic blocking element, respectively.

[0068] Another alternate embodiment 550 is illustrated in Figures 59 through 62. Again, the embodiment 550 is a behind-the-ear housing and microphone construction that includes a first housing half 552 and a second housing half 554 united together to form a unitary housing half 556. As best illustrated in Figure 60, the microphone construction is disposed in a compartment 558. The microphone construction includes a directional microphone 560 that has a first acoustical port 562 and a second acoustical port 564, as best illustrated in Figure 60.

[0069] The acoustical port 564 is acoustically connected to an opening 566 of the housing 556 though acoustical conduit 568. A combination acoustic damper screen 570, O-ring 572 and wind screen 574 complete the construction of opening 566. The damper may be mounted inside the microphone.

[0070] The switching element 576 is much like the switching element 444 of Figures 48 through 52 except that the switching element is slidable in a direction which is referred to as horizontal (primarily due to the illustration in the drawings and not to any use), and is 90 degrees from the movement of the switching element illustrated in Figures 48 through 52. The switching element 576 includes tracks 580 disposed along opposing edges which engage tracks 582 in the housing 556, as best illustrated in Figure 62.

[0071] The switching element includes acoustic opening 584 that is positionable over acoustic port 562 of the microphone 560 and when in combination with O-ring 586 creates an acoustic seal. When the opening 584 is aligned with acoustic port 562, the microphone construction is in a directional mode since sound waves are carried to both ports of the directional microphone 560.

[0072] The switching element 576 also includes an acoustical blocking element 590, as best illustrated in Figure 60, and when in combination with O-ring 592, in position over acoustic port 562, the microphone construction is then in an omni-directional mode since sound waves are blocked from the acoustic port 562 of

the microphone 560. The switching mechanism 576 includes a finger tab 596 to aid in pushing the sliding mechanism back and forth in the general direction of arrows 598, as best illustrated in Figure 59.

Claims

1. A microphone construction for use in a hearing aid, the construction comprising:

   a housing having first and second acoustic passages communicating with a microphone retaining chamber, each acoustic passage extending through the housing to an exterior surface thereof; and
   a microphone disposed within the microphone retaining chamber and having first and second acoustic ports in an acoustic relationship with the first and second acoustic passages, respectively.

2. The construction of claim 1 comprising:

   a switching mechanism secured to the housing and movable between a first position wherein the first and second acoustic passages are in an acoustic receptive state and a second position when the first passage is blocked by the switching mechanism and the second passage is an acoustic receptive state.

3. The construction of claim 2 wherein the switching mechanism is rotatably secured to the housing and is rotatable between the first position and the second position.

4. The construction of claim 2 wherein the switching mechanism is slidably secured to the housing.

5. The construction of claim 4 wherein the switching mechanism includes one acoustic port.

6. The switching mechanism of claim 4 wherein the switching mechanism does not include an acoustic port wherein the switching mechanism is manipulated to place either the first or second acoustic opening in either a receptive acoustic state or a non-receptive acoustic state.

7. The construction of claim 4 wherein the switching mechanism is slidable in a vertical or in a horizontal direction.

8. The construction of claim 3 wherein the construction is included in a behind-the-ear hearing aid or in an in-the-ear hearing aid.

9. The construction of claim 3 or 4 and further including first and second acoustic ports within the switching mechanism being in an acoustic relationship with the acoustic passages of the housing when the switching mechanism is in the first position, and a third acoustic port for being in an acoustic relationship with the first acoustic passage when the switching mechanism is in the second position.

10. The construction of claim 9 wherein O-rings are secured to the first, second and third acoustic ports such that the acoustic ports are in a sealing relationship with a surface of the housing providing an acoustic seal with the first and second acoustic passages when in the first position and an acoustic seal when in the second position between the third acoustic port and second passage.

11. The construction of claim 3 wherein the switching mechanism includes a plurality of outwardly projecting tabs for engagement to rotate the switching mechanism between the first and second positions.

12. The construction of claim 3 and further including first and second stop tabs projecting outwardly from the housing and a stop member projecting from the switching mechanism, the stop member engaging the first stop tab thereby positioning the switching mechanism in the first position and whereby when the switching mechanism is rotated the stop member engages the second stop tab to position the switching mechanism in the second position.

13. The construction of claim 3 and further including first and second O-rings being disposed between the first and second ports of the microphone and the first and second acoustic passages of the housing to provide an acoustic seal.

14. The construction of any of the preceeding claims comprising:

    first and second compressable seals positioned between the first and second acoustic passages and the first and second acoustic ports to provide an acoustic seal therebetween.

15. The construction of claim 14 wherein the first and second compressible seals are O-rings preferably made of a silicone adhesive.

16. The construction of any of the preceeding claims wherein the housing is formed from first and second matching housing halves joined together, the first housing half having the first acoustic passage and a second housing half having the second acoustic passage, the housing halves having a microphone retaining chamber.

17. The construction of any of the preceeding claims wherein the switching mechanism is capable of manipulating the first acoustic passage or the second acoustic passage but not both acoustic passages.

18. The construction of claim 1, wherein the housing comprises

a faceplate moving a first acoustic opening, a second acoustic opening and a mechanism for attaching a switching mechanism, wherein
the microphone includes a first acoustic port and a second acoustic port, wherein the microphone is secured to a first surface of the faceplate; and wherein
a first acoustic passage connects the first acoustic opening in the faceplate to the first acoustic port on the microphone; and
a second acoustic passage connects the second acoustic opening in the faceplate to the second acoustic port in the microphone.

19. The construction of claim 18 wherein the first acoustic passage and the second acoustic passage are welded onto the microphone or retained to the microphone by a retaining clip.

20. The construction of claim 18 wherein the microphone is retained against a first surface of the faceplate by a retaining block.

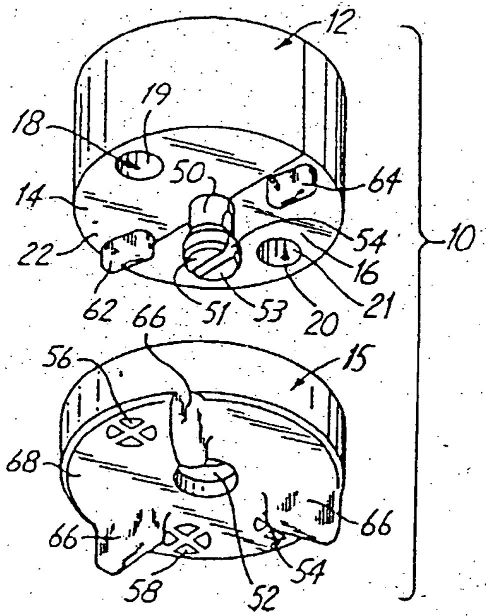
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Fig. 1

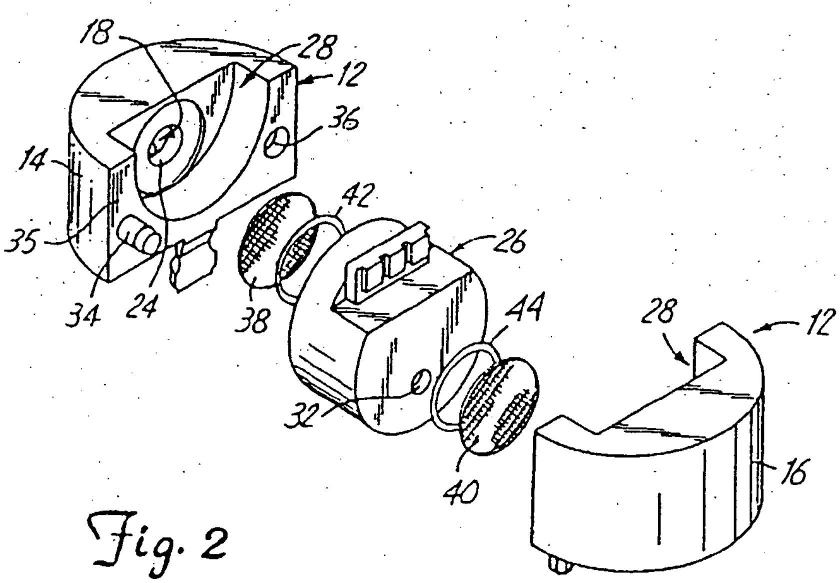
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Fig. 2

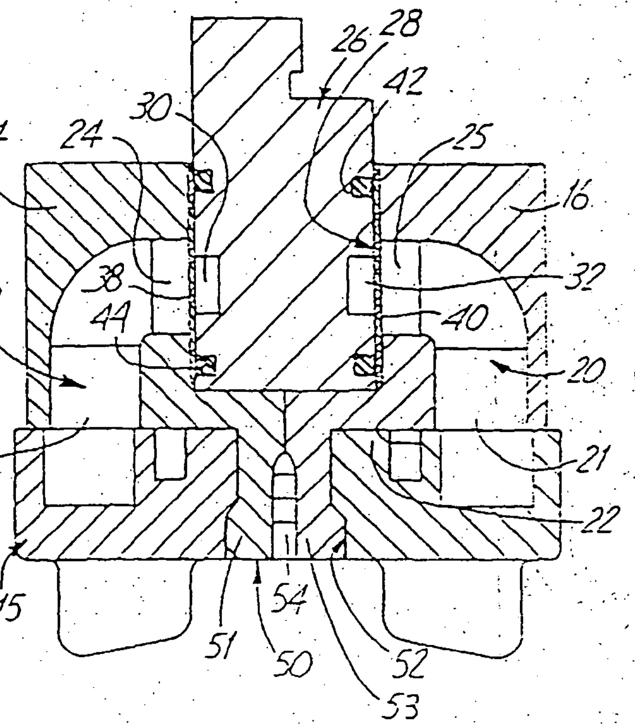
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Fig. 3

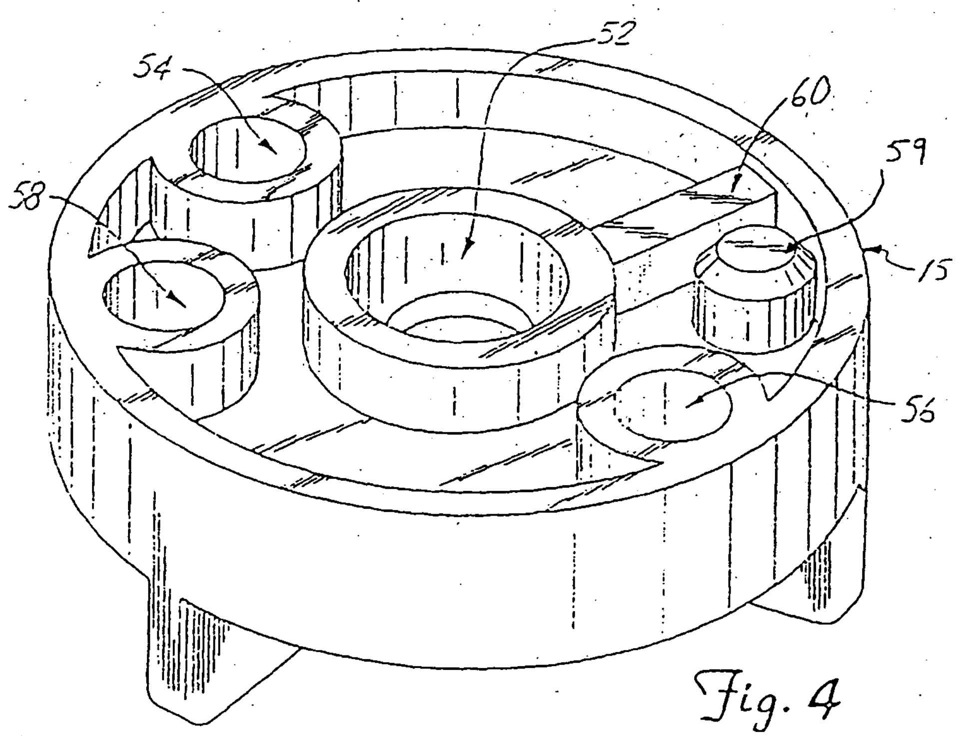
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Fig. 4

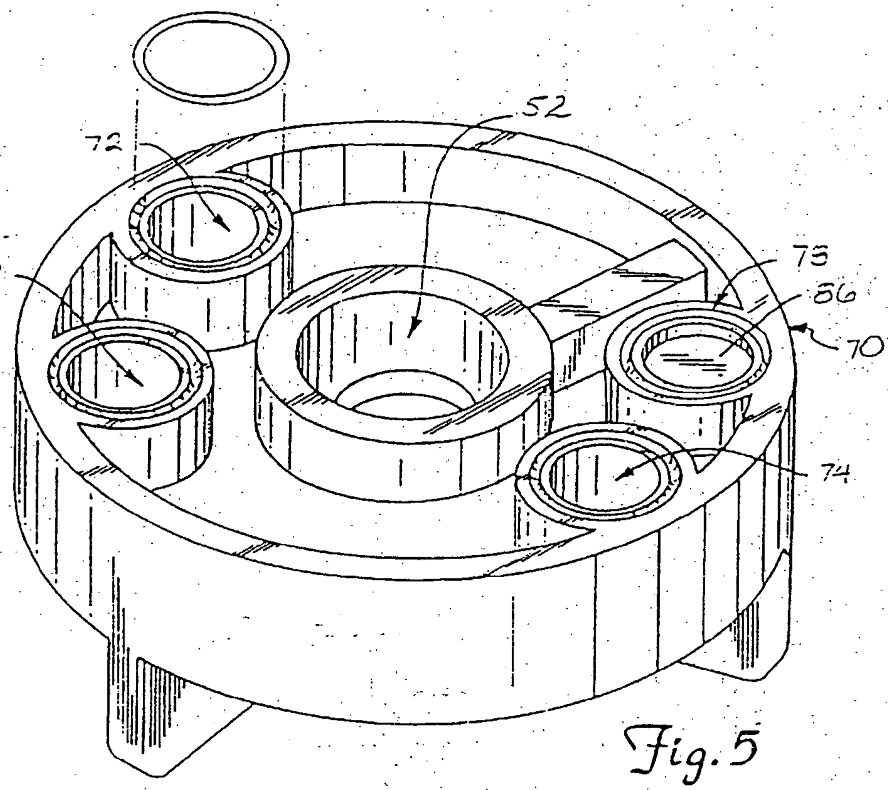


Fig. 5

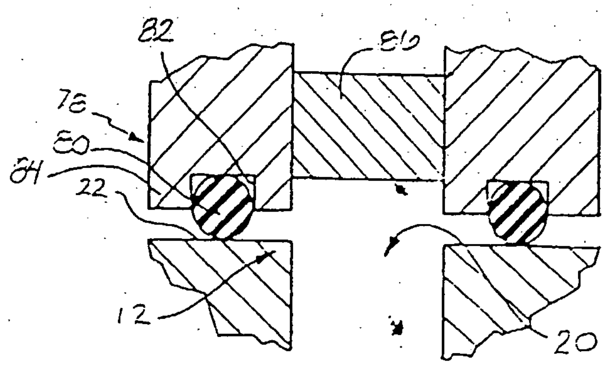


Fig. 6

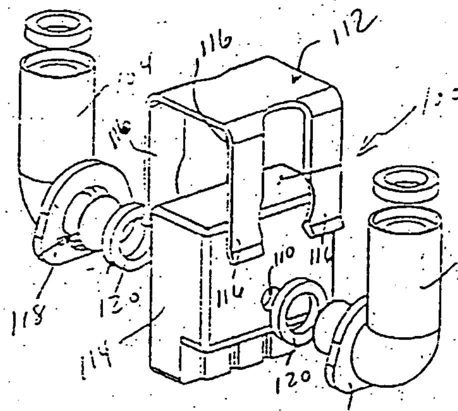


FIG 7

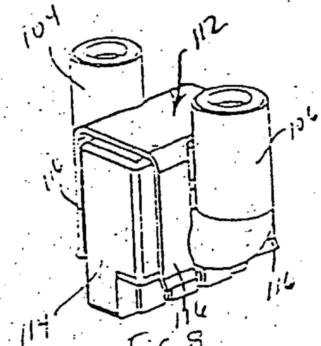


FIG 8

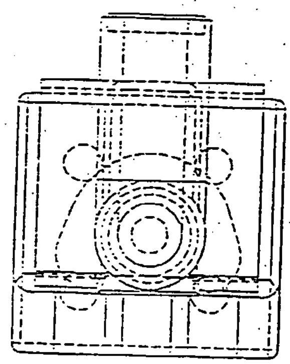


FIG 9

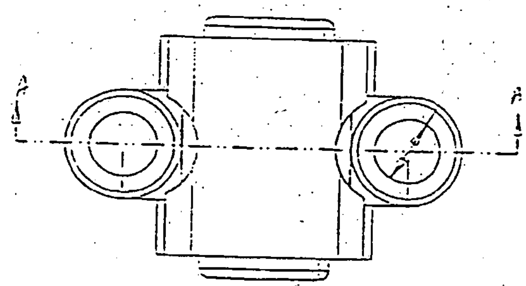


FIG 10

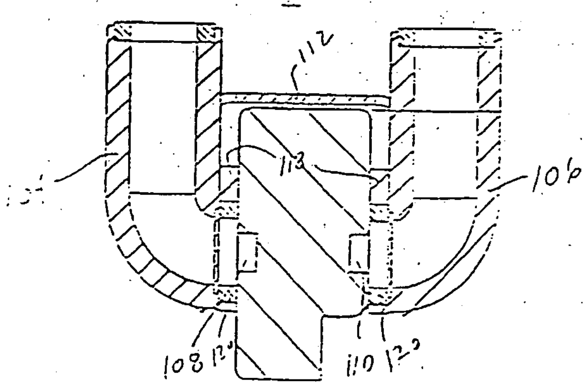


FIG 11 Section A-A

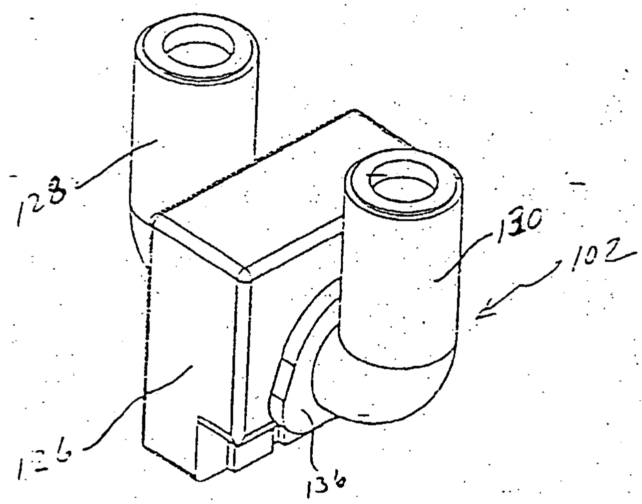


FIG 12

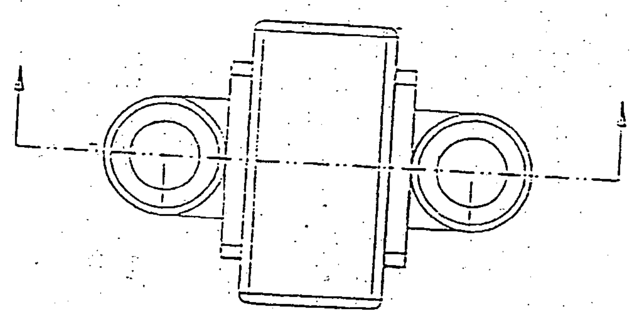


FIG 13

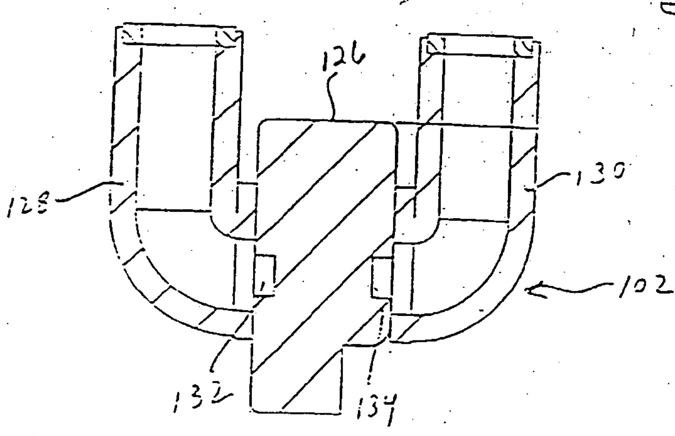


FIG 14

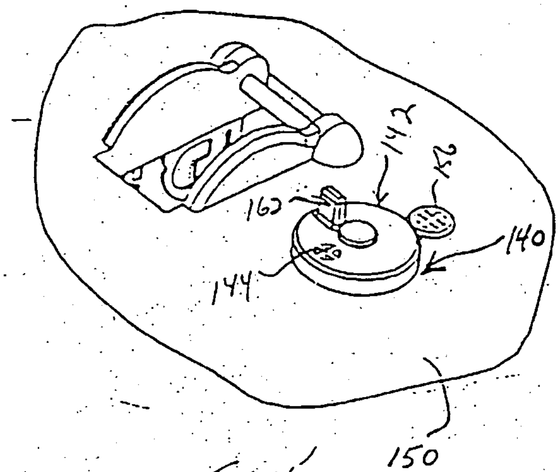
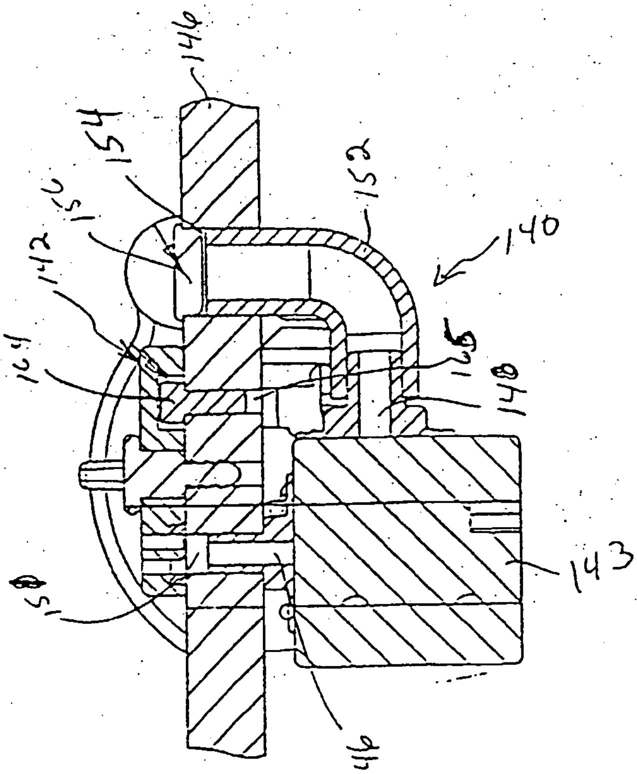


FiG 15



SECTION A-A

FiG 16

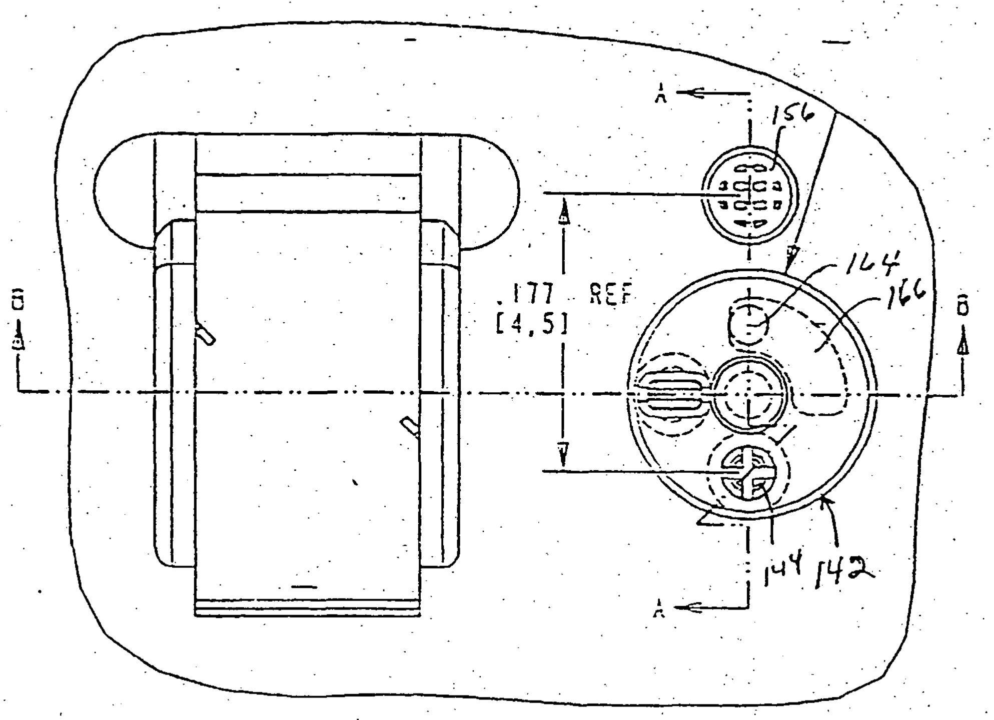


FiG 17

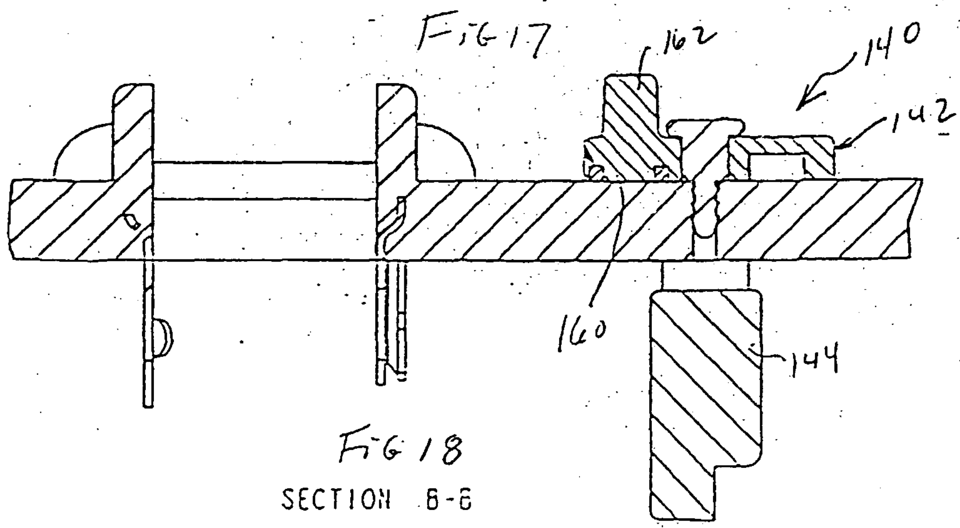


FiG 18
SECTION B-B

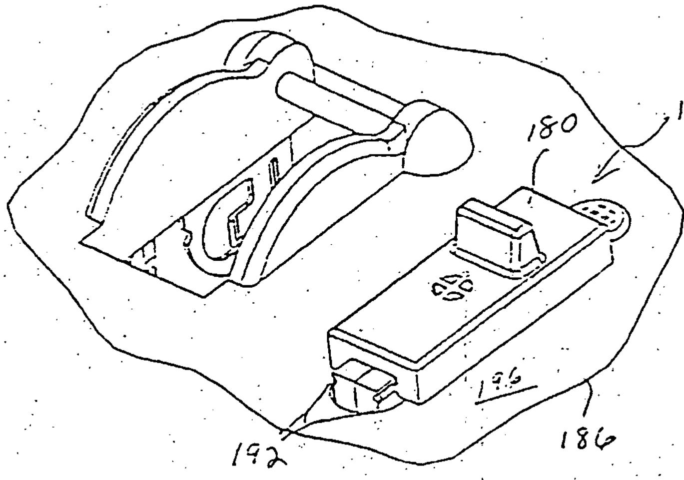


Fig 19

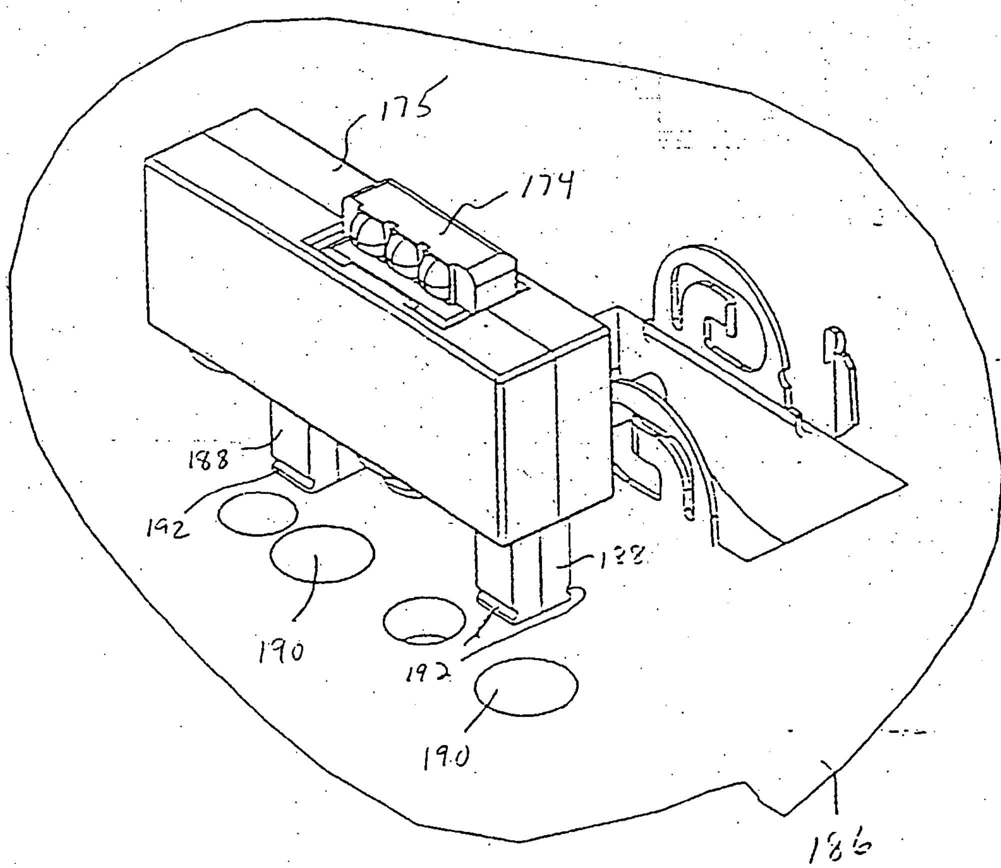


Fig 20

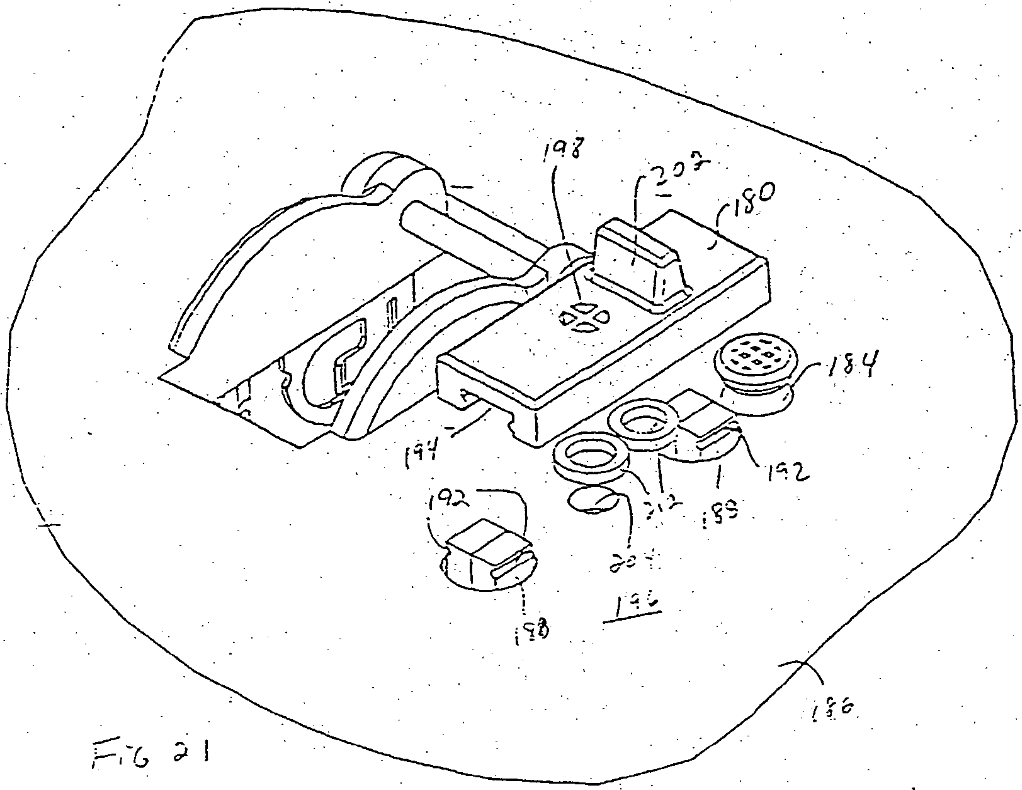

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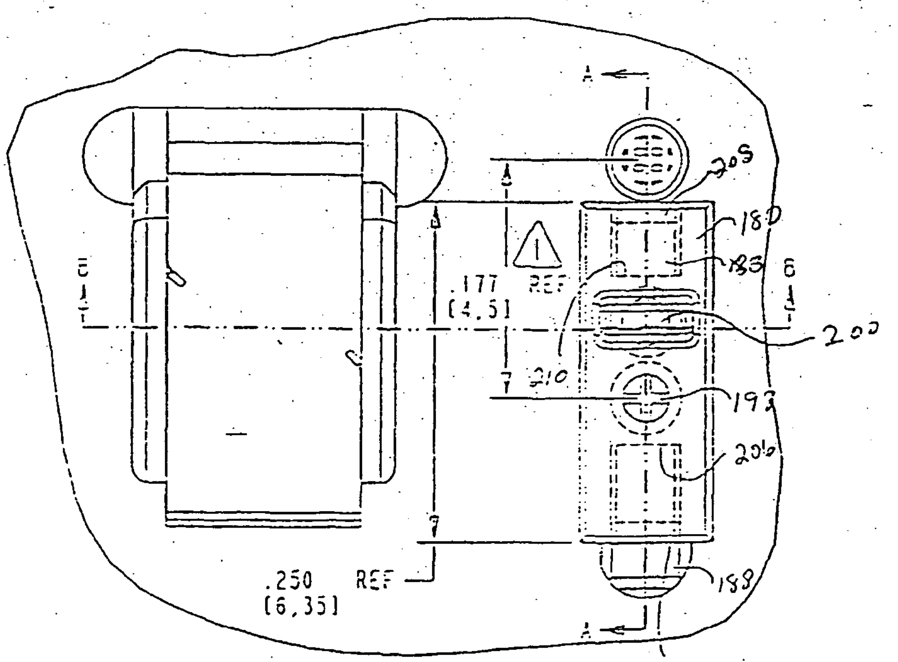
Fig 21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.250 REF
[6,35]
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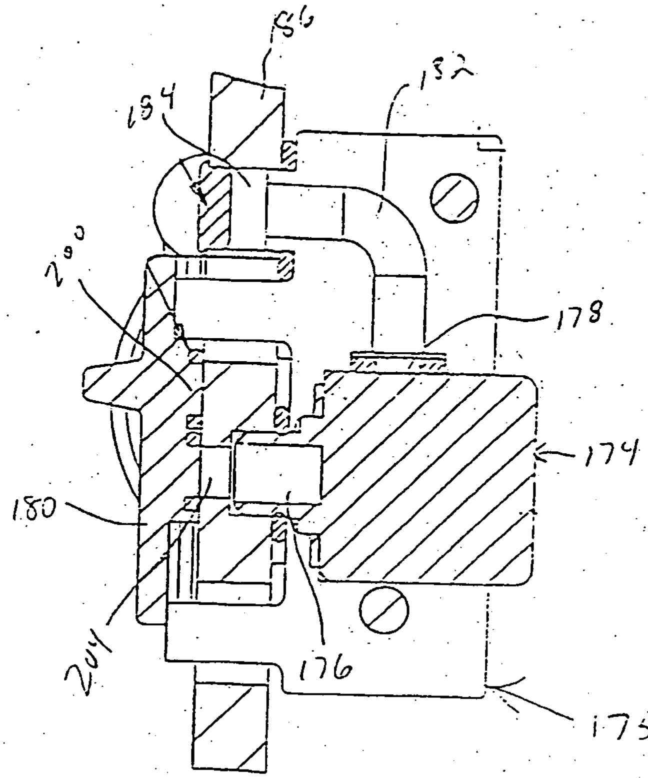
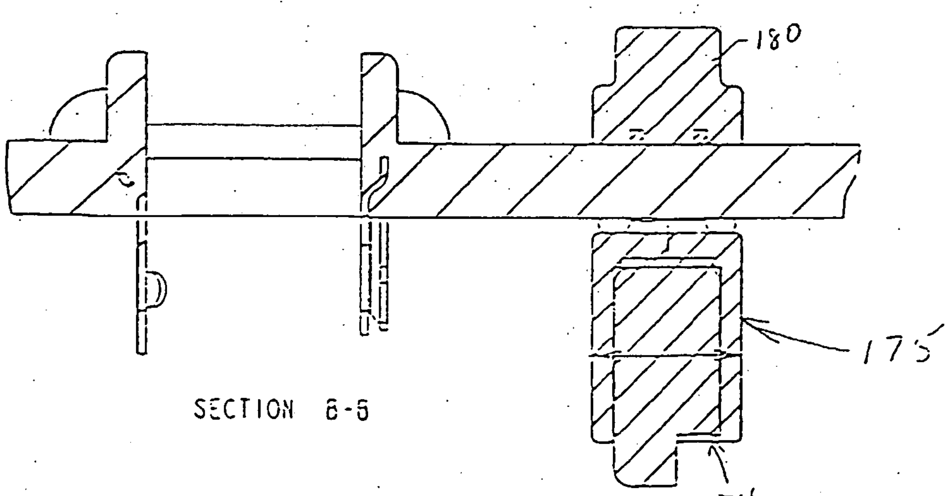
A
194

Fig 22



SECTION A-A

Fig 23



SECTION B-B

Fig 24

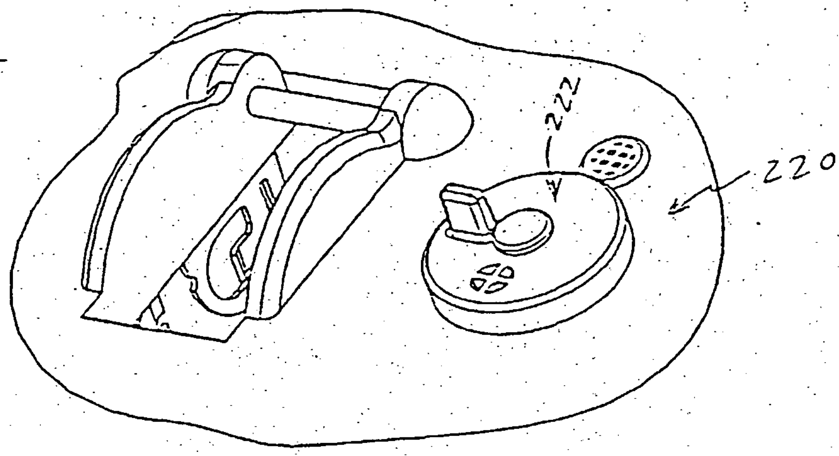


FiG 25

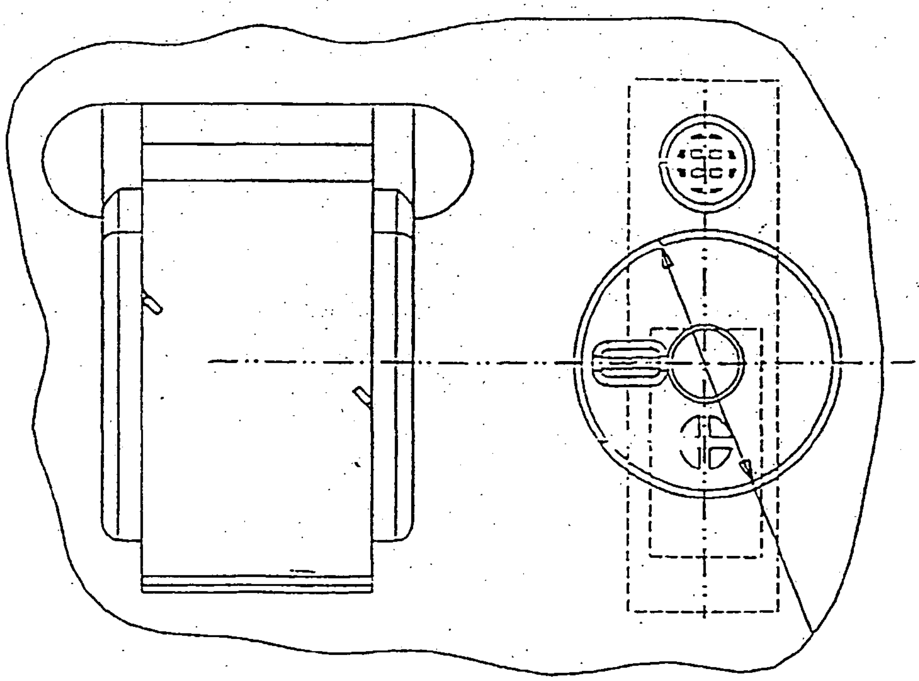


FiG 26

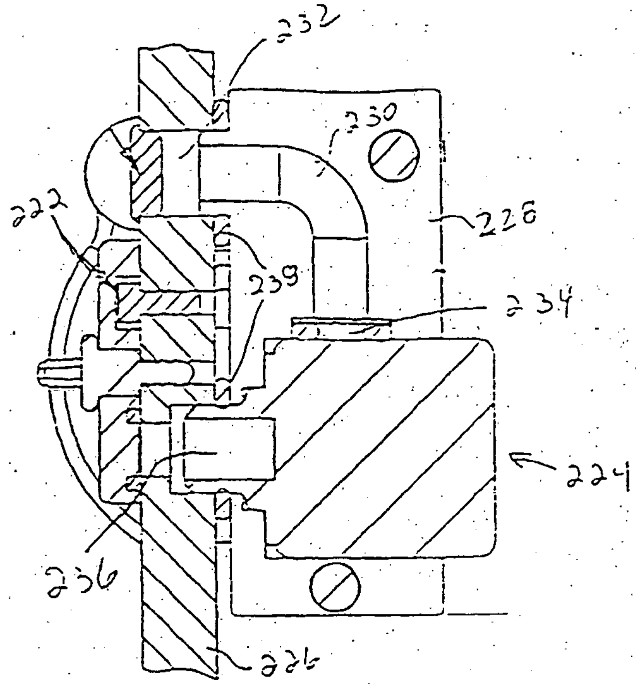


FIG 27

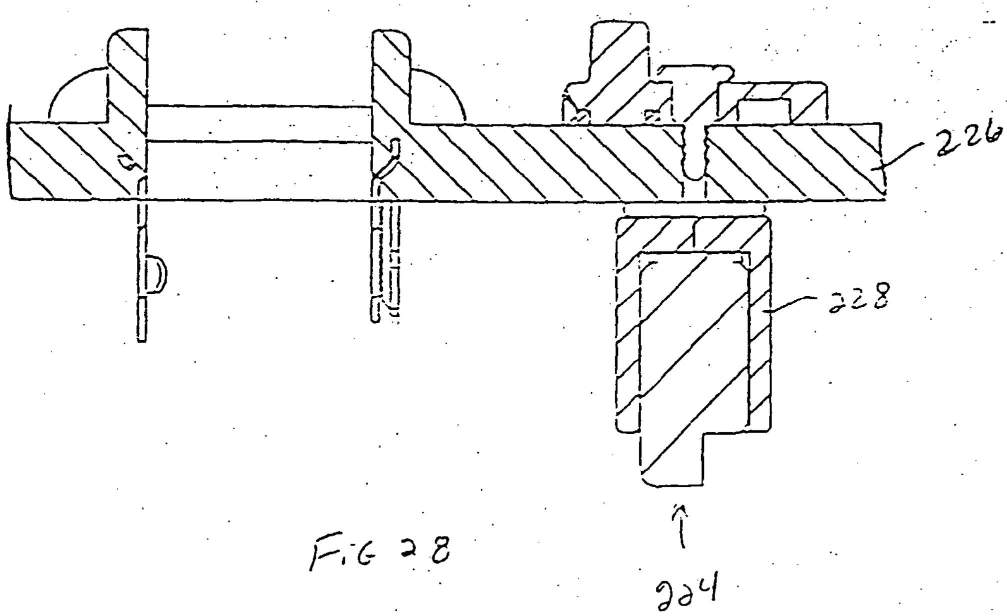


FIG 28

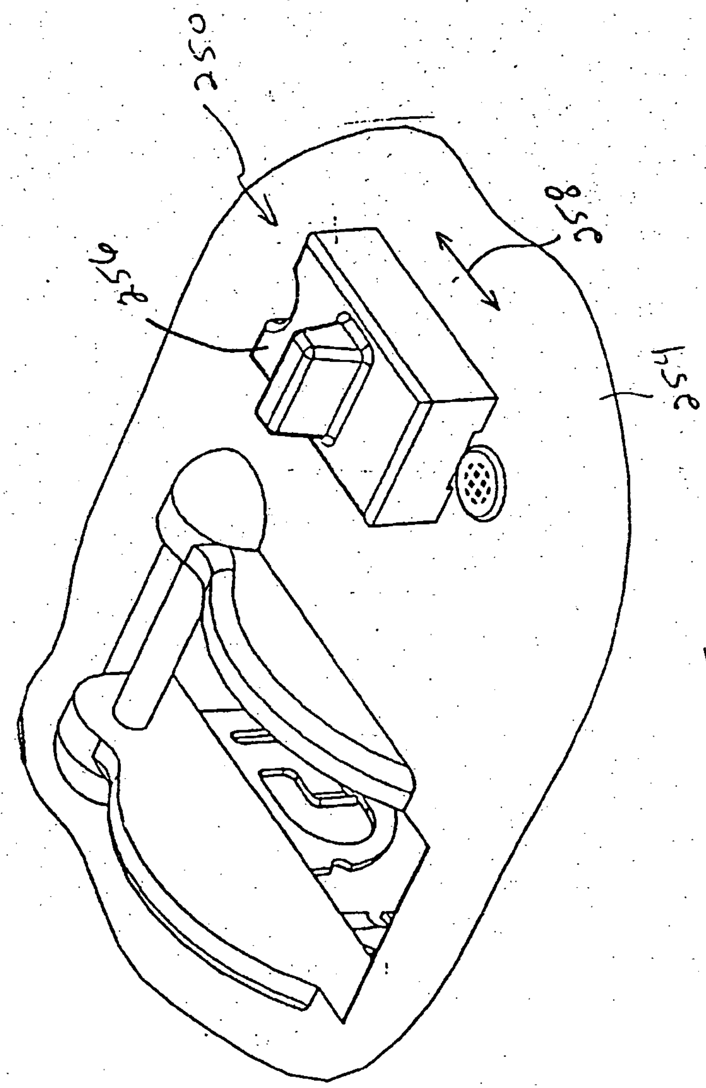


Fig 29

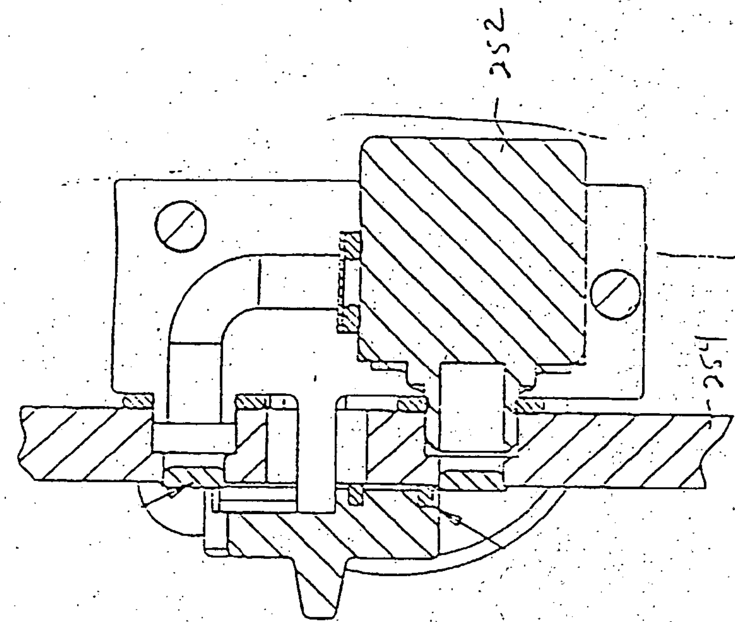


Fig 31

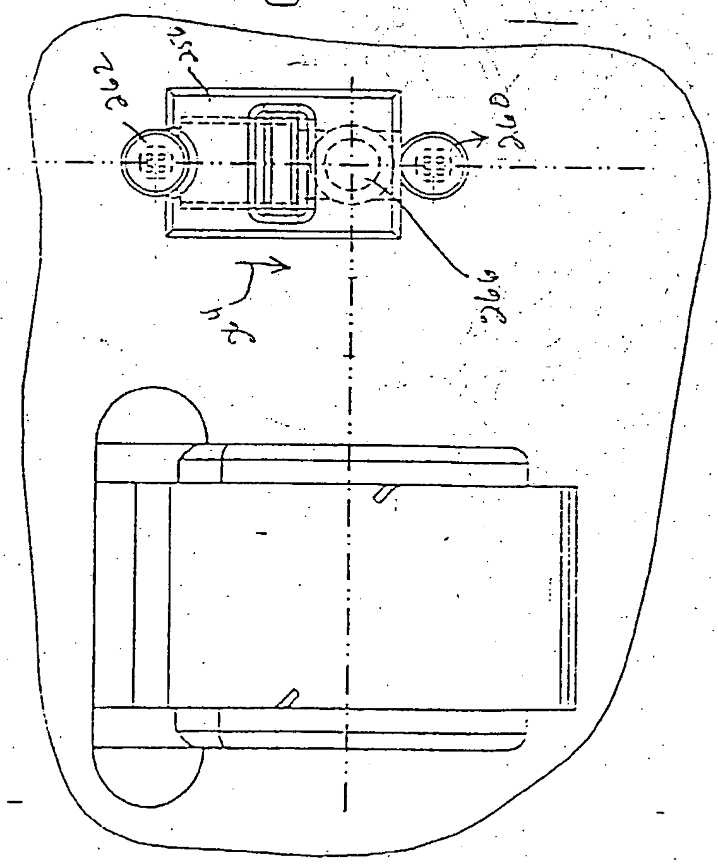


Fig. 30

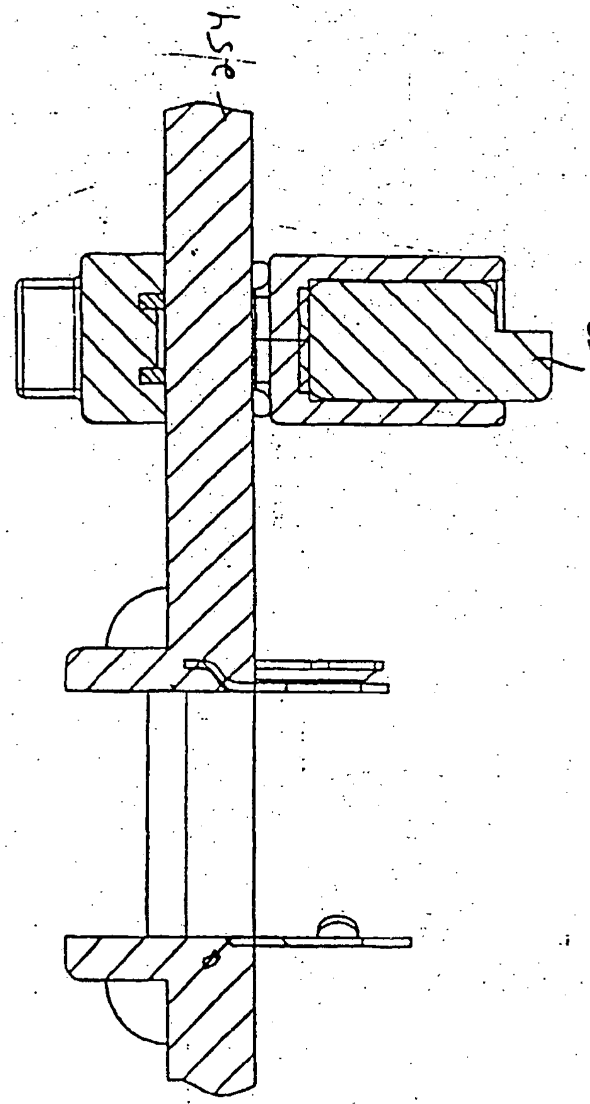


Fig 32

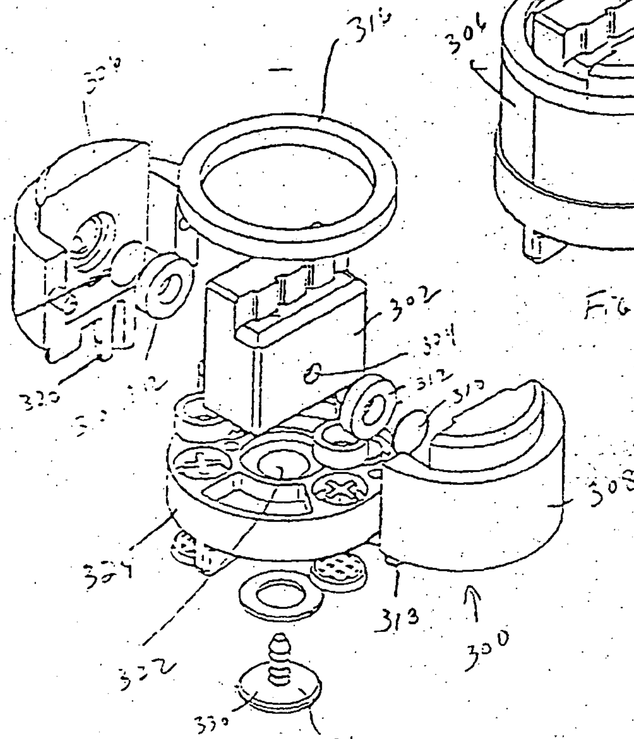


Fig 33

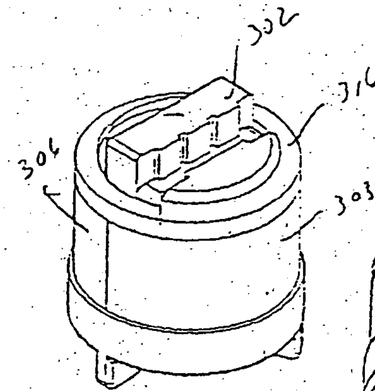


Fig 34

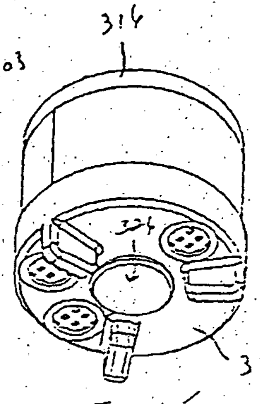


Fig 35

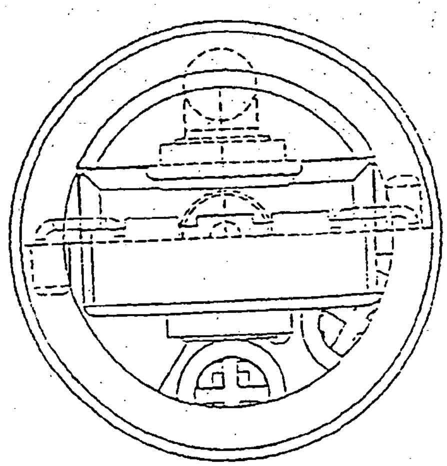
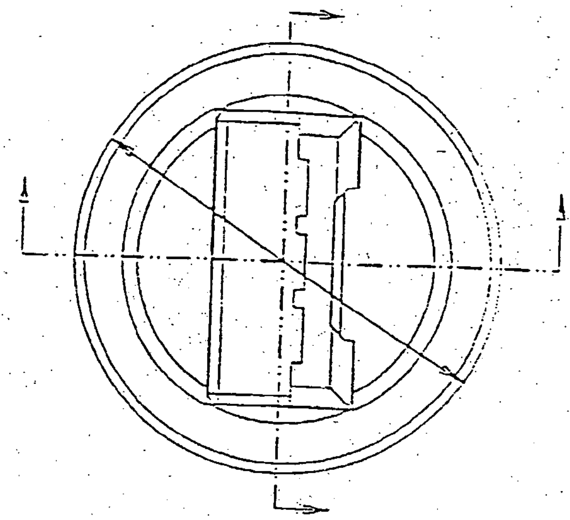
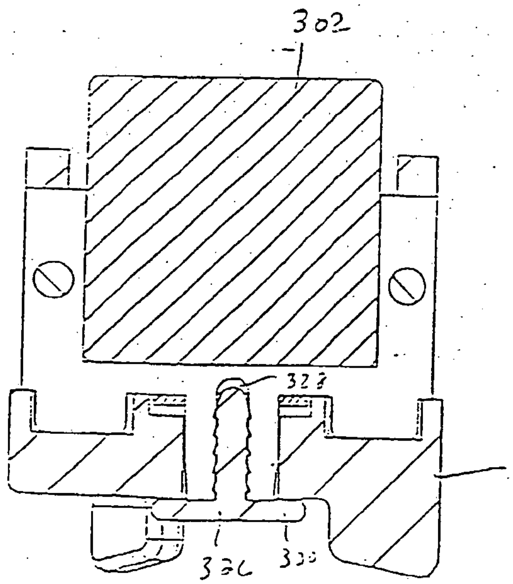


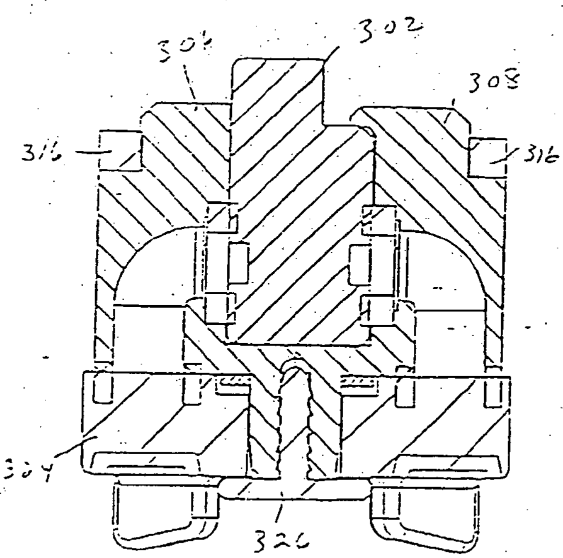
Fig 36



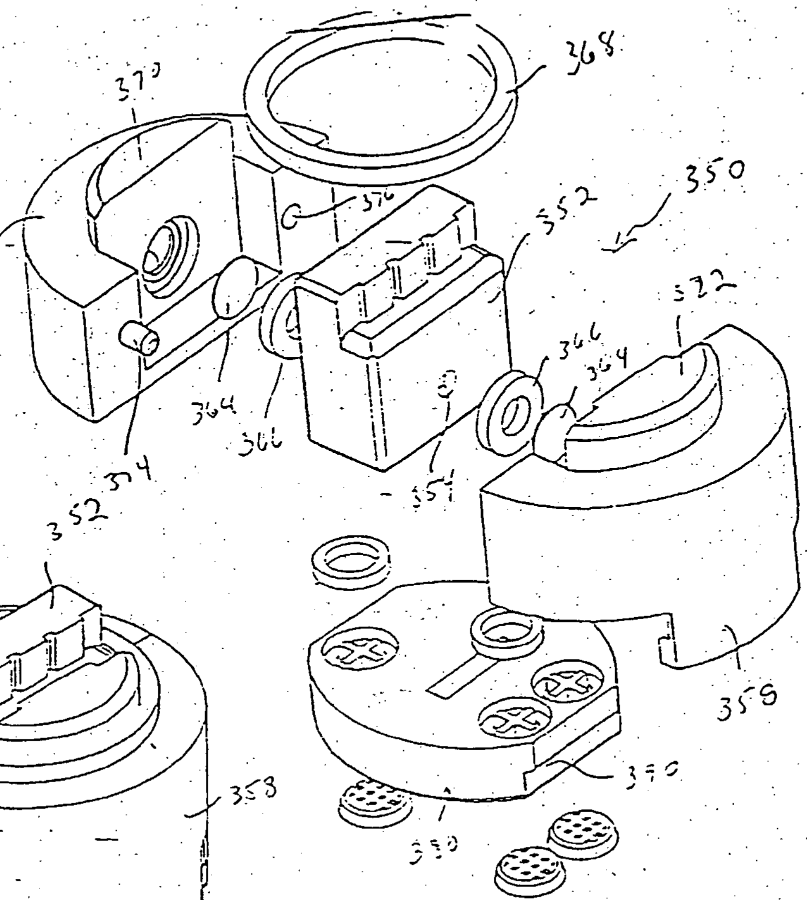
F.G 37



F.G 38



F.G 39



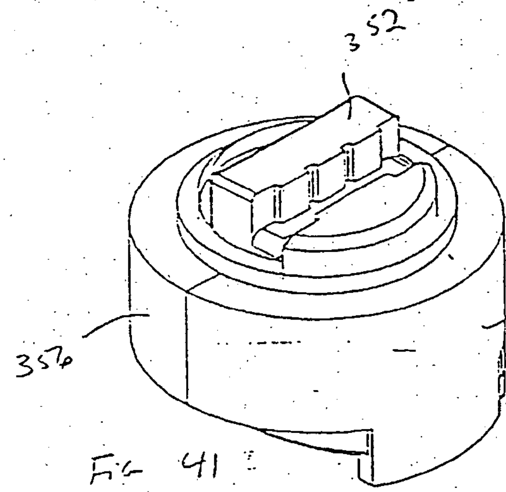


Fig 41

Fig 40

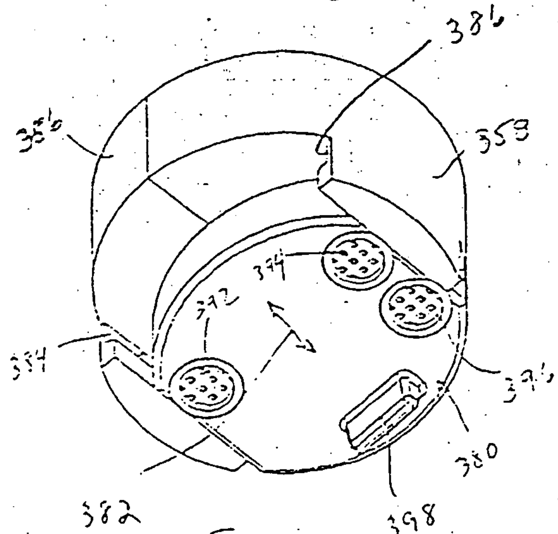


Fig 42

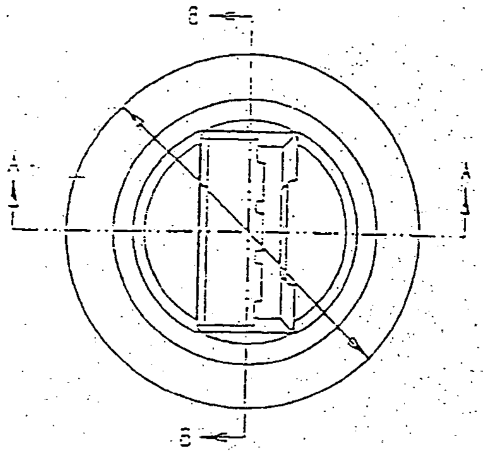
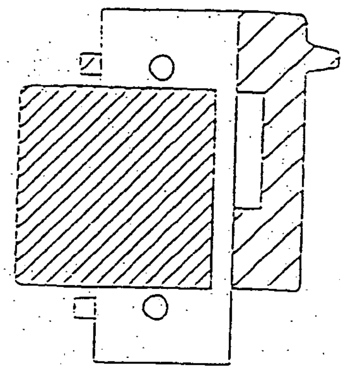
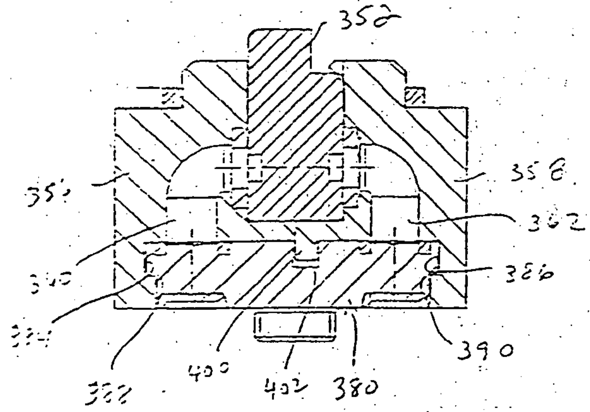


FIG 43



SECTION B-B

FIG 46



SECTION A-A

FIG 44

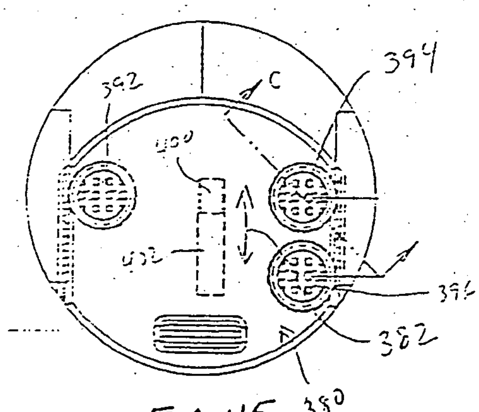
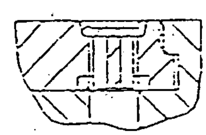


FIG 45



SECTION C-C

FIG 47

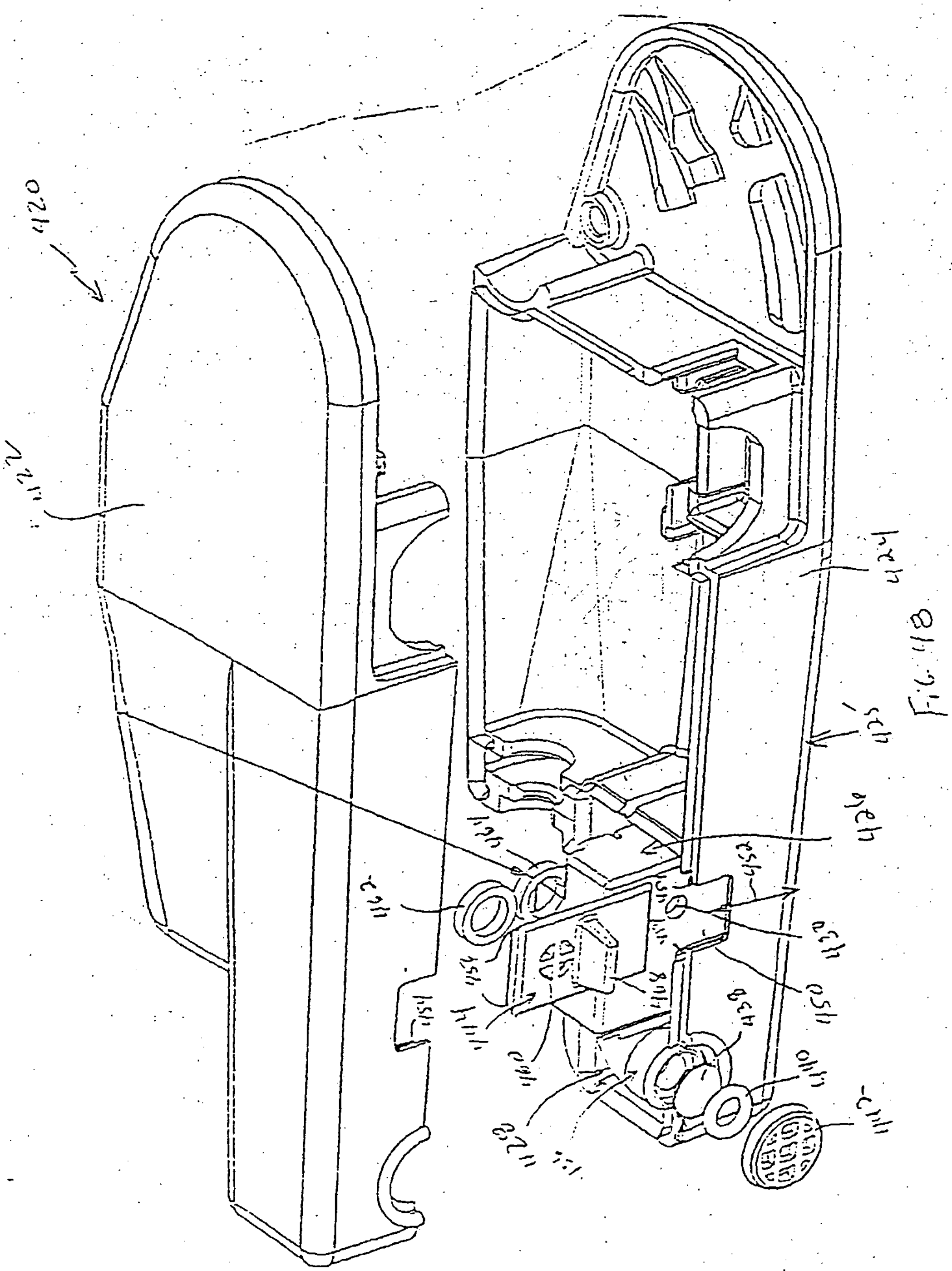


Fig. 18

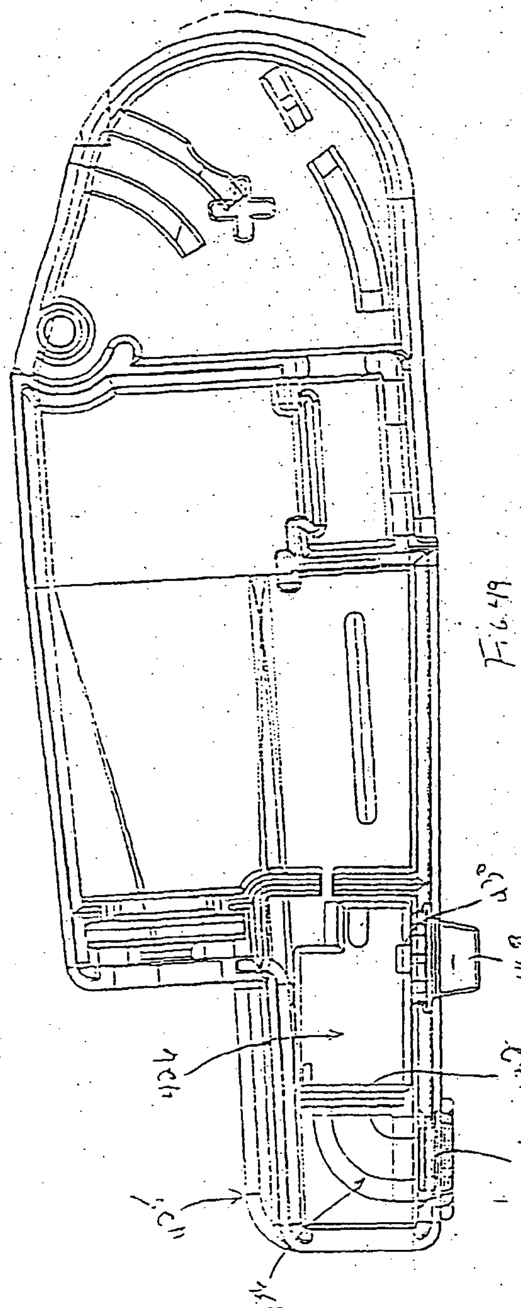
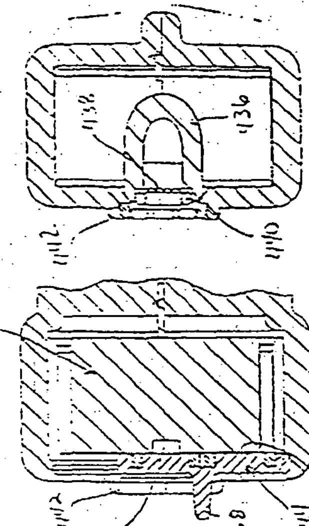


Fig 49



SECTION A-A

Fig 51

SECTION B-B

Fig 52

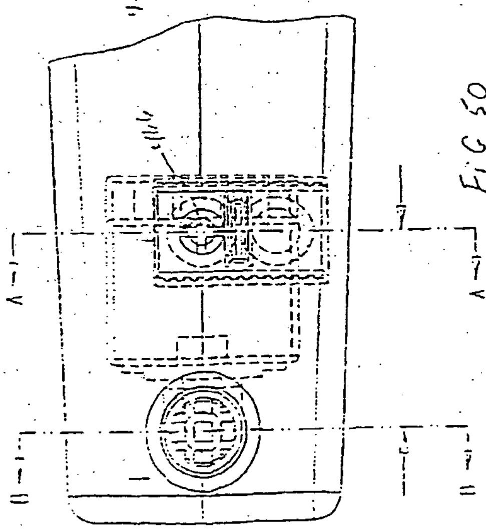


Fig 50

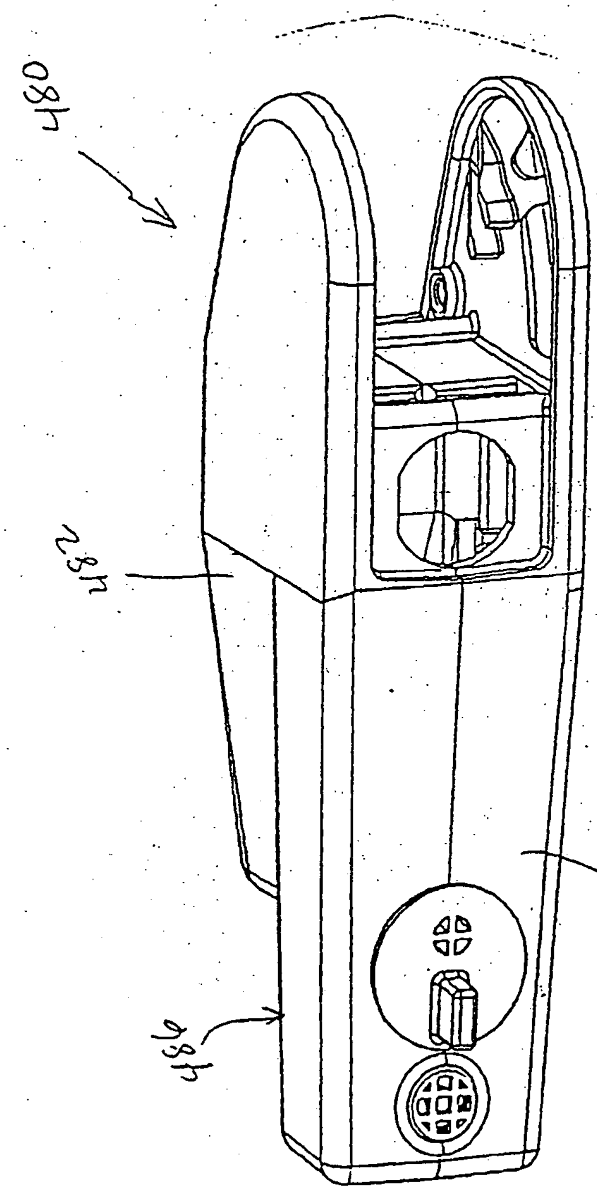


Fig. 53

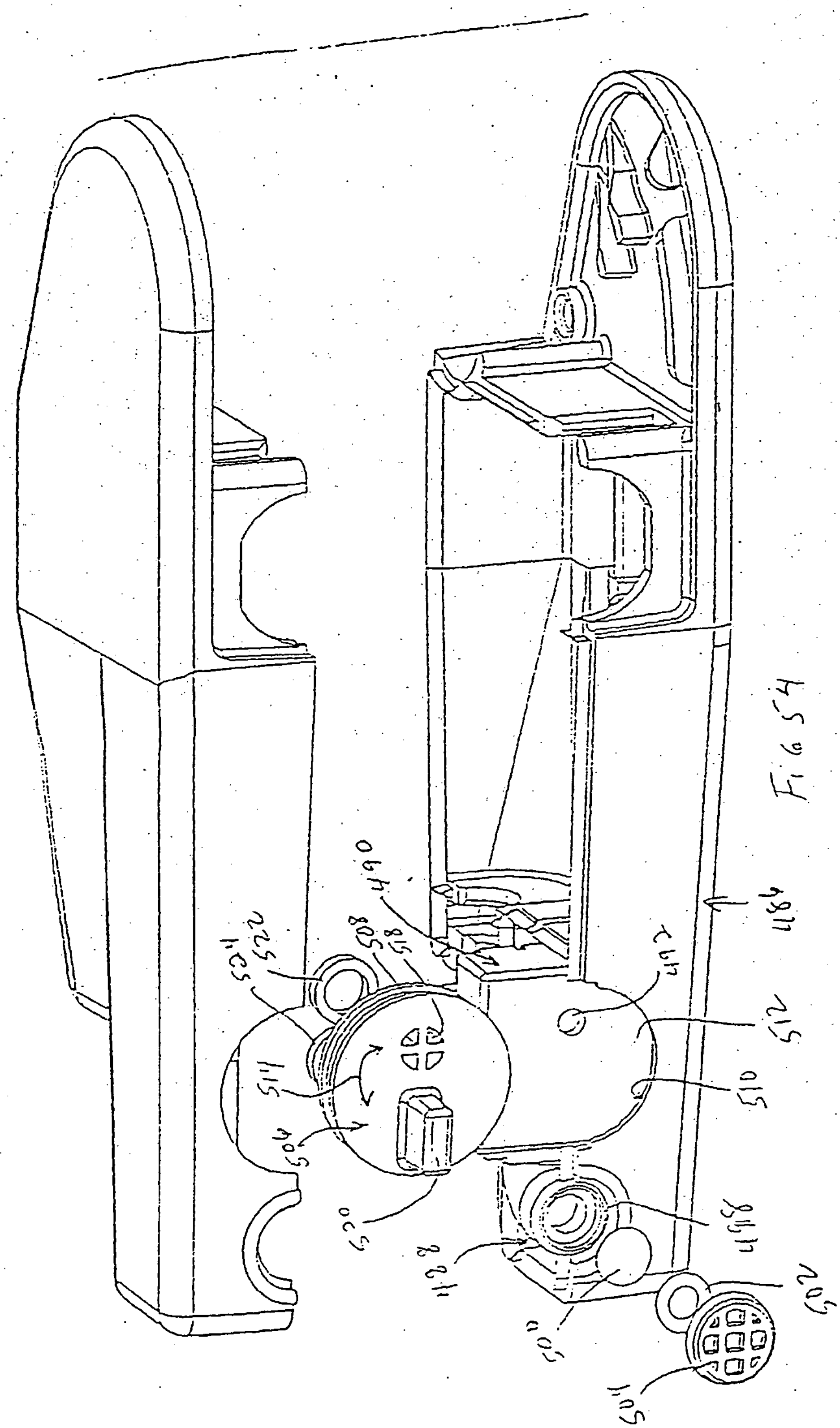


Fig 54

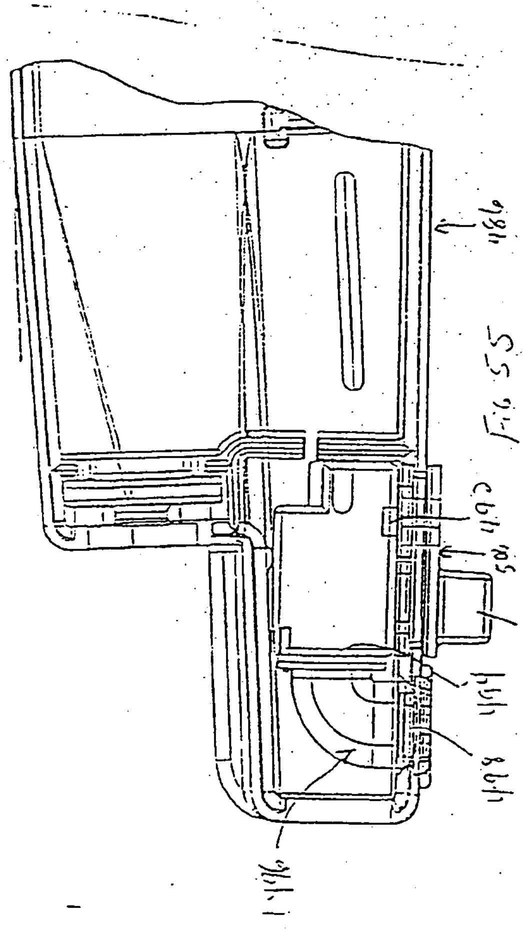
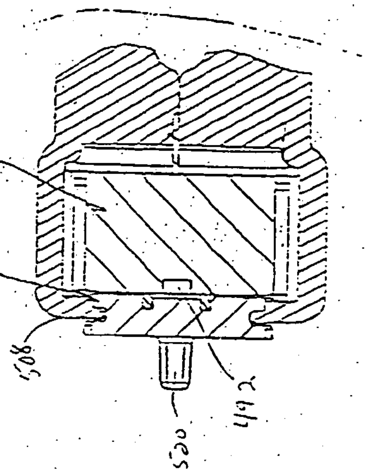


Fig 55



SECTION A-A

Fig 57

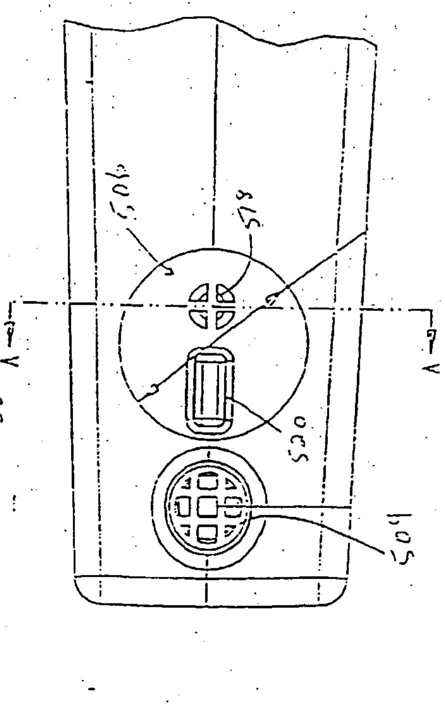


Fig 56

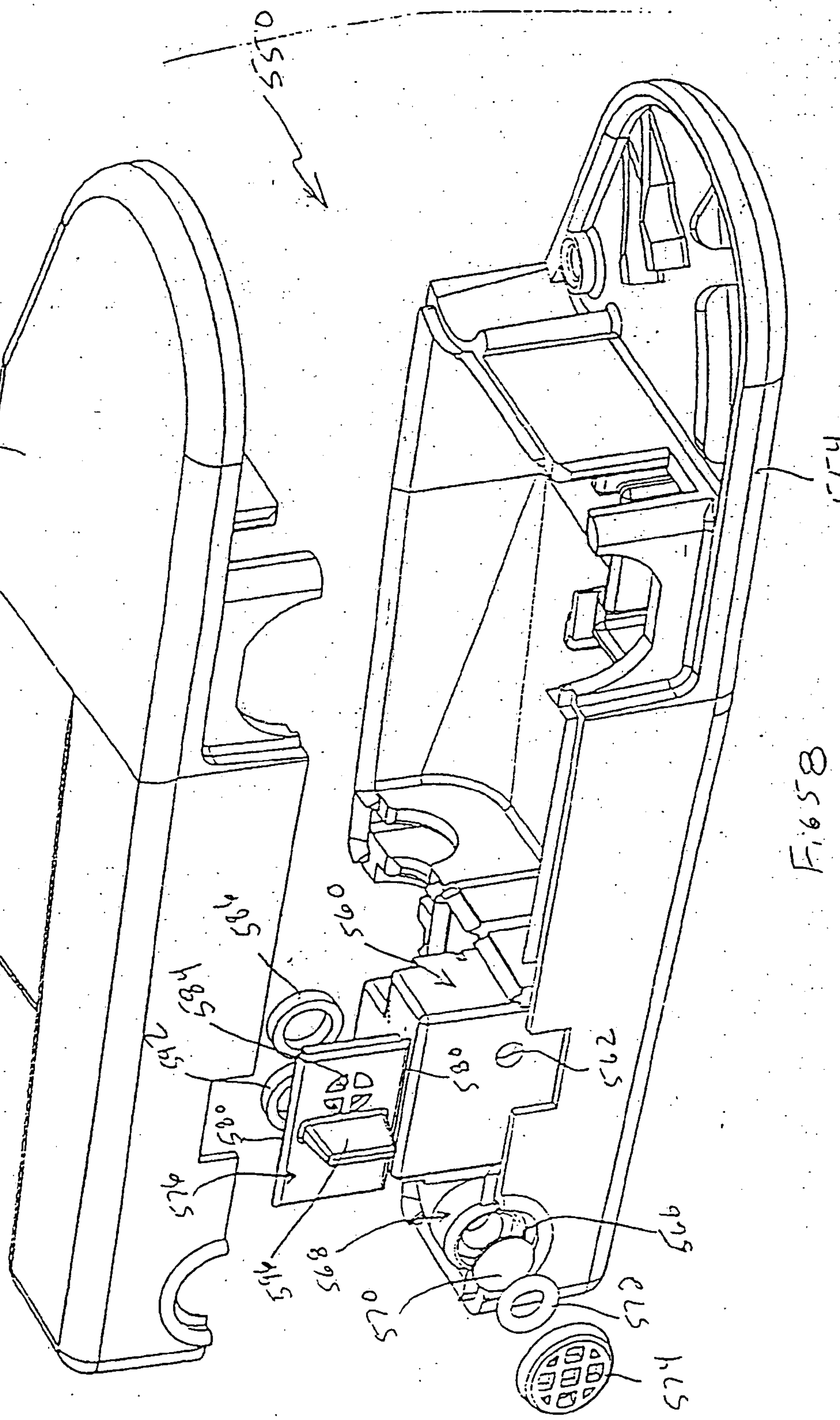


FIG 58

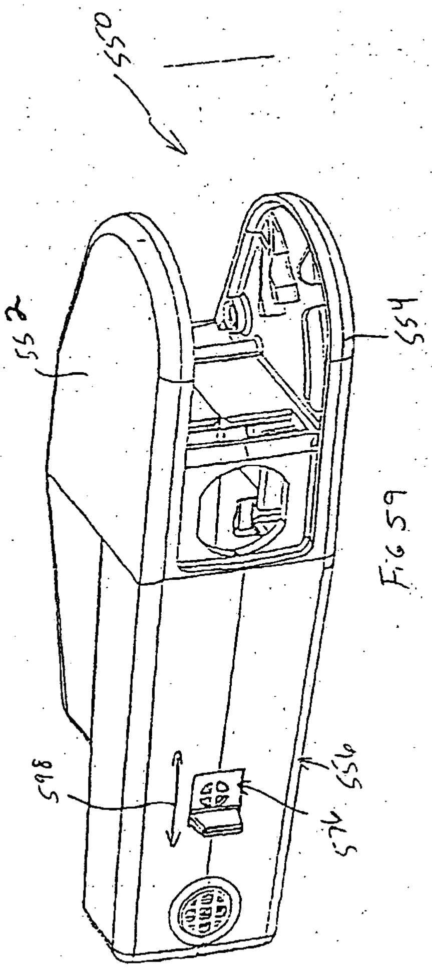


FIG 59

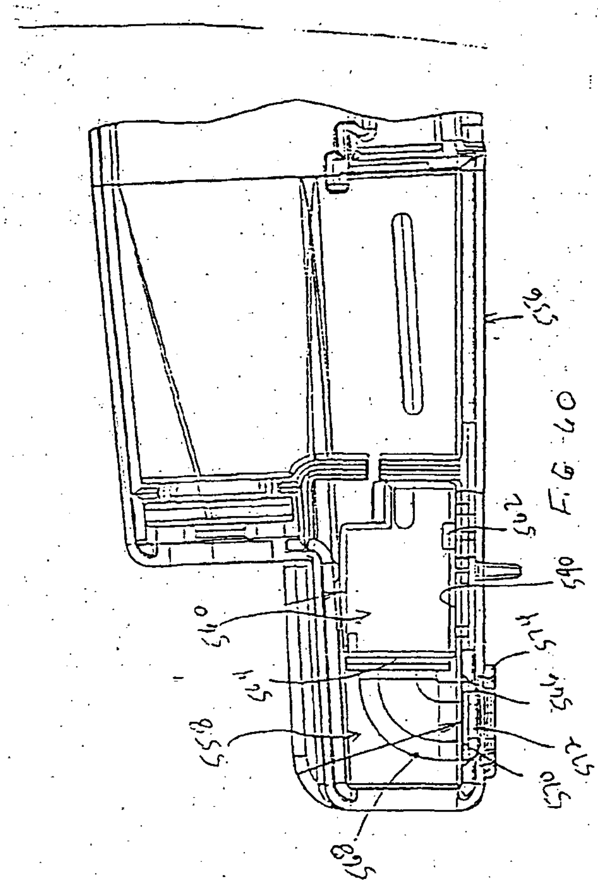


FIG 60

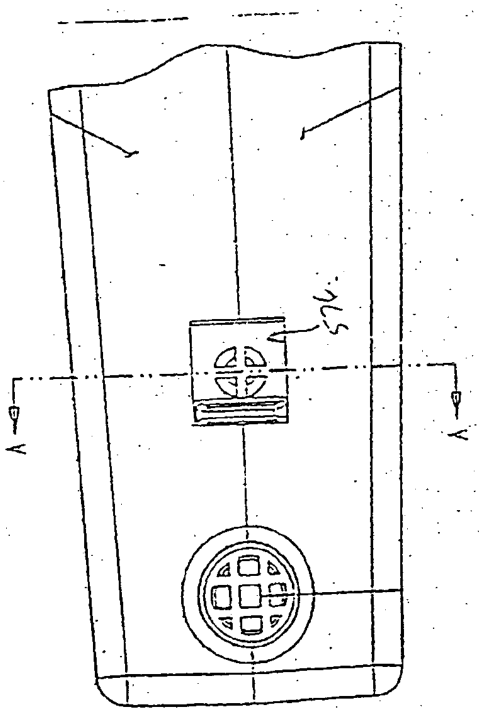
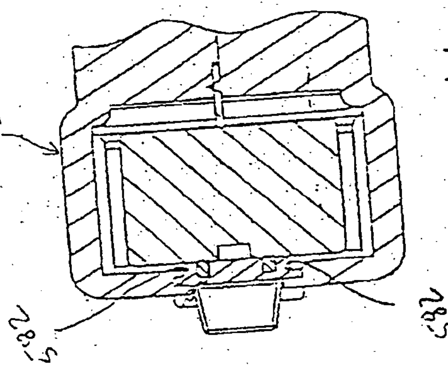


Fig 61



SECTION A-A

Fig 62

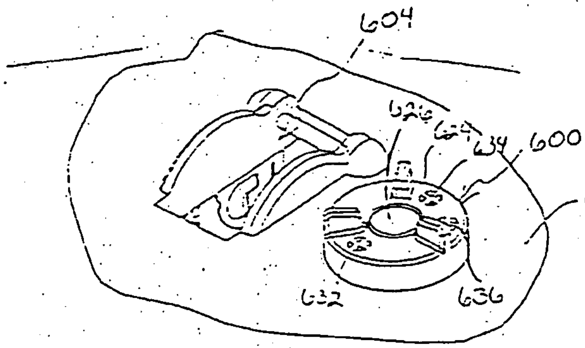

604
626
624
634
600
602
632
636

Fig. 63

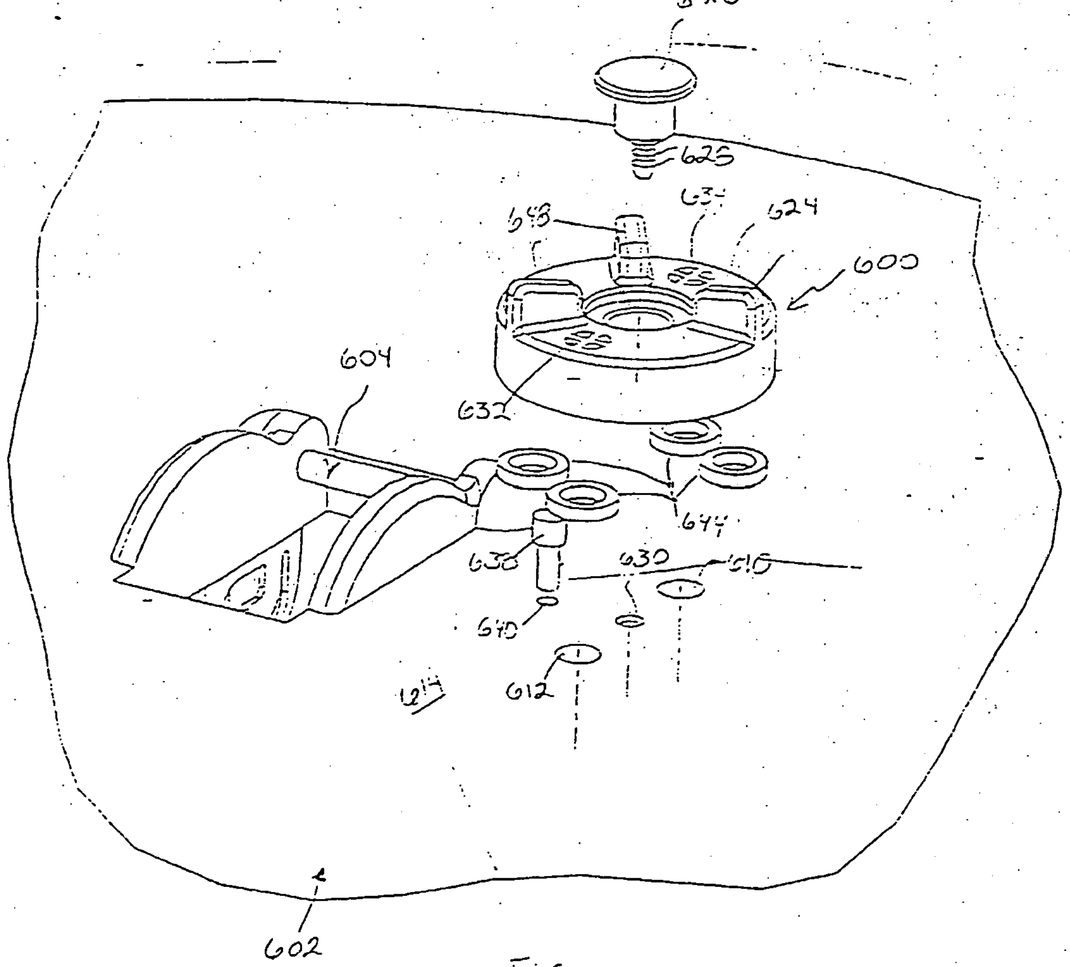

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Fig. 64

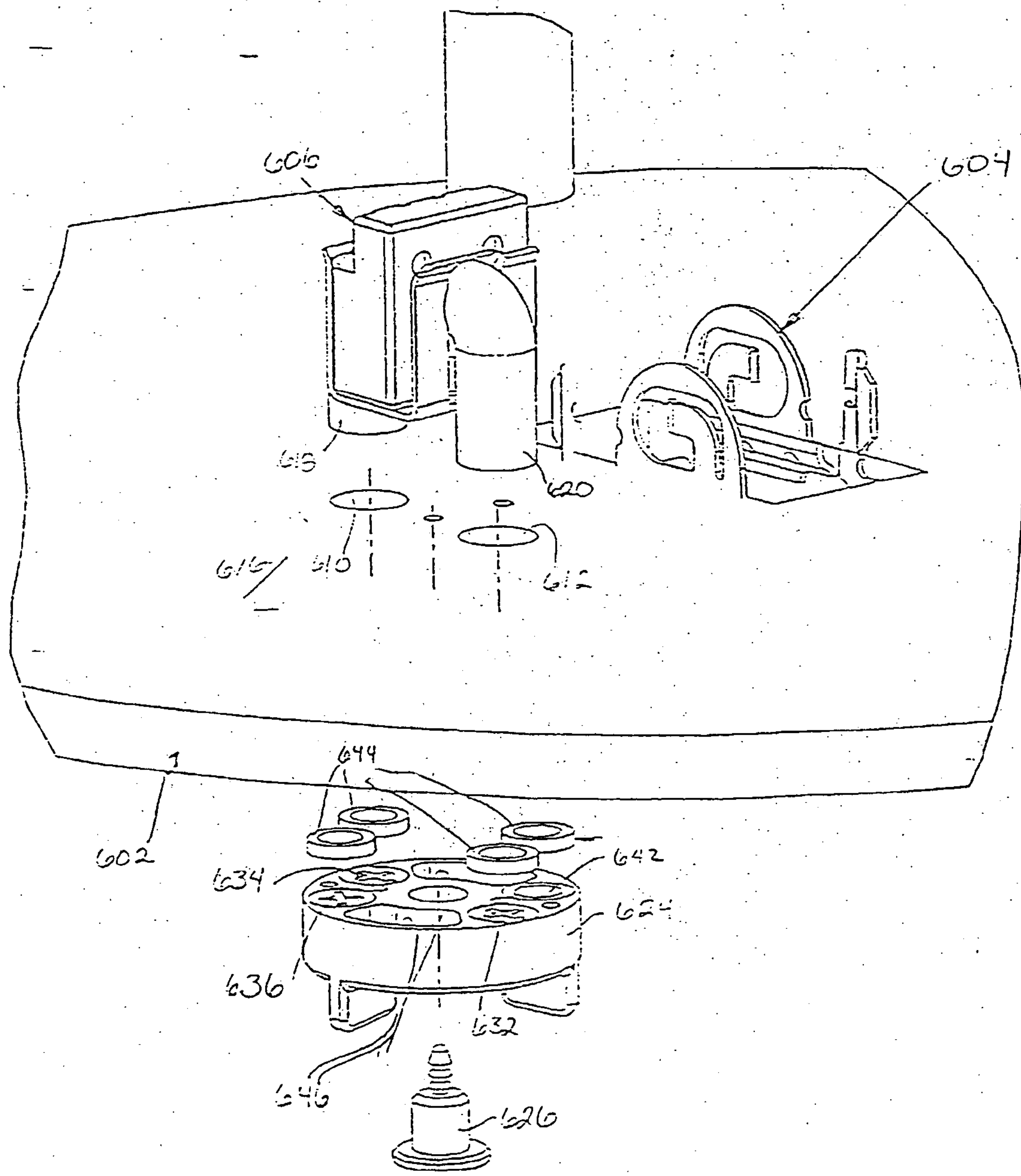


Fig 65

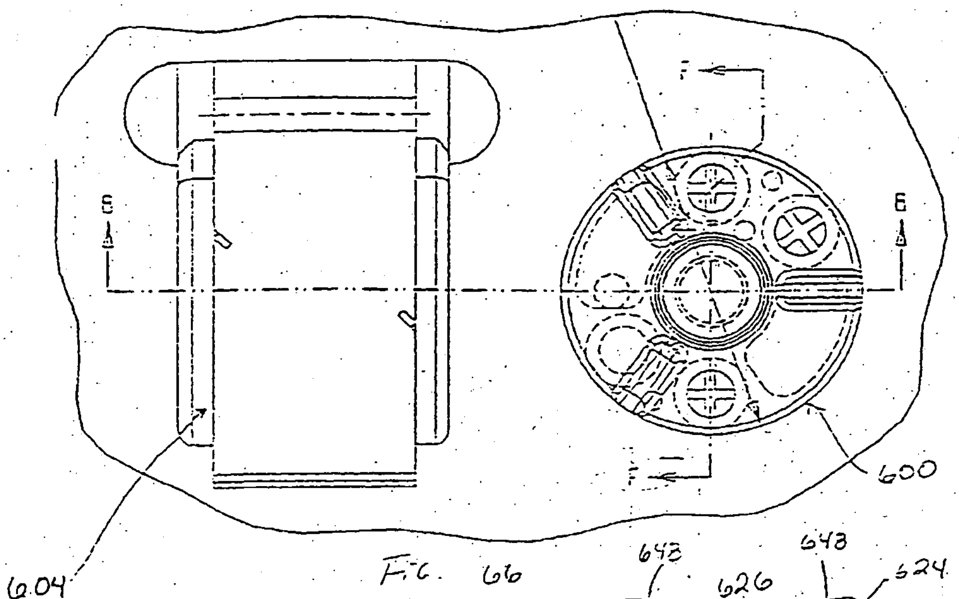
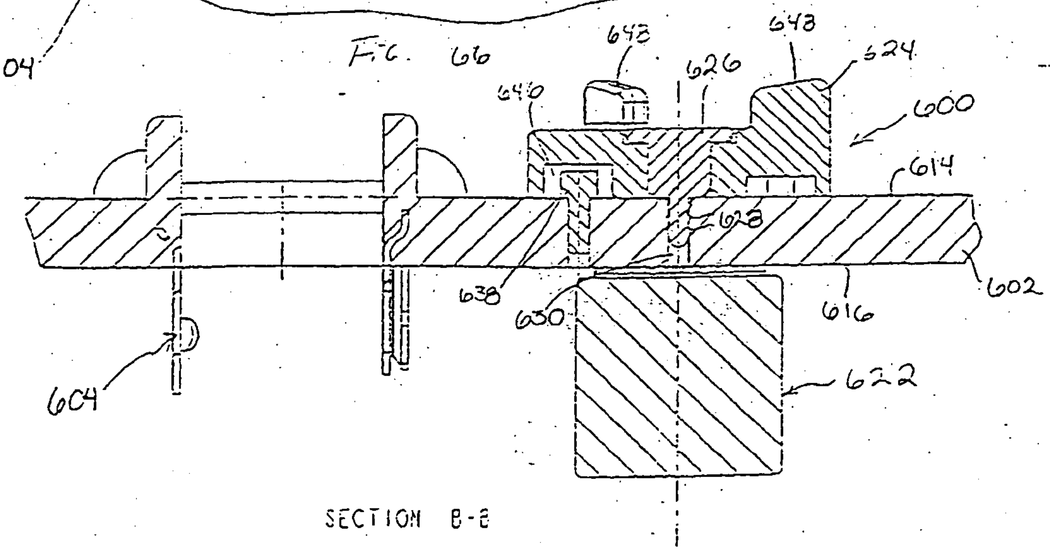

B
B
600
604

Fig. 66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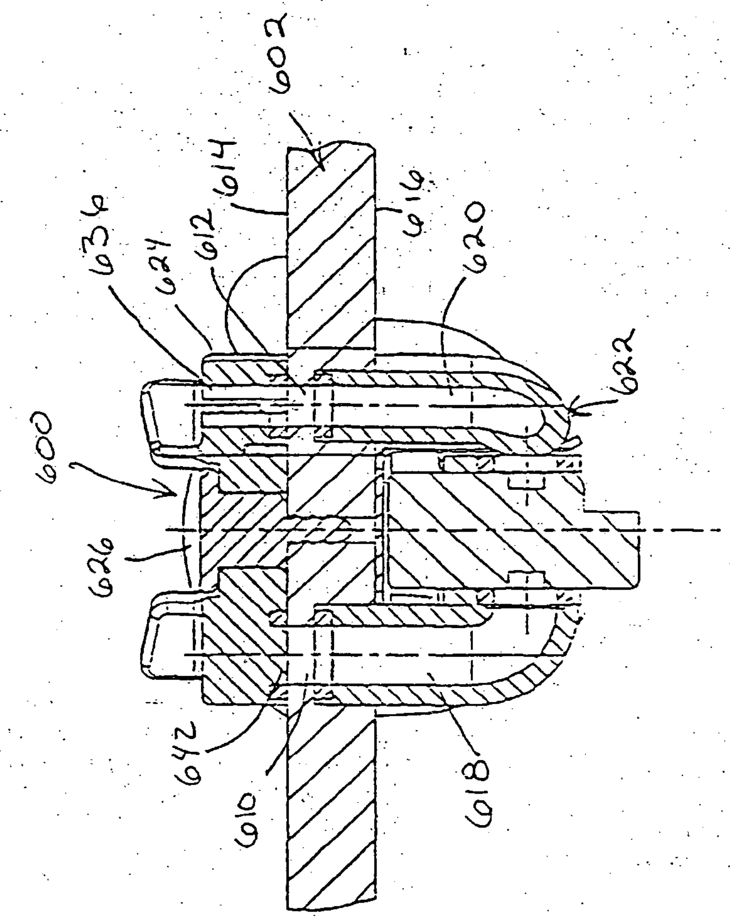
622
SECTION B-B

Fig. 67



SECTION F-F

FIG 68